DESIGN IN NATURE'S STORY

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BY

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PREFACE

In certain countries it becomes a matter of importance that the encroachment of Sand Dunes and destruction of neighbouring good soil be interrupted. In some of these art is employed, in the plantation of suitable trees, to oppose the onward march of sand; in others, Nature comes to the aid of MAN when she plants on some arid tract the lowly Marram Grass. This poor plant can do little or nothing with its thin leaves to arrest the blown sand, but in such regions the value of sand is rated so low that no superior powers interpose to prevent the downward passage, towards moisture, of the straggling roots of the plant, which show their gratitude to the sand by binding it together. By these means an oasis is produced, and this in turn affords a base of supply and protection for higher forms of vegetation. The fruitful soil may then be saved by the valuable barrier opposed by these nobler plants.

Some such work as that of the Marram Grass is attempted here, in a field neglected and unpromising enough. It must be admitted that the study of teleology is in a parlous state. It is more than neglected, it is under scientific ban. Valuable as were the writings of Paley and the Bridgewater Treatises, their somewhat contracted and too anthropomorphic views are perhaps no longer tenable in the presence of modern enlightenment. At all events final causes are out of fashion with current science, which relegates them to "the burrow of superstition" and "the ladder of metaphysics." Singularly enough, metaphysics is by many removed from the hierarchy of sciences, and this renders the strangling of teleology an easy matter. In this connection, however, the three important works of the late Duke of Argyll, "The Reign of Law," "The Unity of

Nature," "The Philosophy of Belief," must be mentioned with all honour for their service to teleology. I think the present position is fairly represented by saying that, in the pursuit of science, ætiological investigation is keenly and with much profit pursued, but that of teleological considerations it is held "their introduction is the ruin of all science."

If Marram Grass be planted here and there, on the borders of some fruitful soil, this short essay will have fulfilled its purpose.

The argument here maintained rests upon two pillars—the adaptation of organisms for their environments on the one hand, and, on the other, the adaptedness of environments for coming organisms. Apology is needed for the simplicity and brevity of the illustrations from the side of the organisms, which alone might furnish matter for elaborate treatises by experts, were they willing to consider it, but which would be out of place here. Such value as the argument possesses rests upon the *concurrent* testimony to Design in Nature, furnished by the two groups of facts.

Much help is thankfully acknowledged from such well-known works as Prof. Jeffrey Bell's "Comparative Anatomy and Physiology," Mr. Lyddeker's "Royal Natural History," Mr. Reynolds' "Vertebrate Skeleton," and Professor Reynolds Green's "Manual of Botany."

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INTRODUCTION

"If God did not exist we should be obliged to invent Him,"* was one of Voltaire's sound sayings.

"The whole frame of nature bespeaks an intelligent Author," said Hume, the prince of sceptics.

Such acknowledgments as these are not without their present value for those who maintain a teleological view of the universe. They show that such a view was a necessity of thought for great and free-thinking minds even at that period when Bishop Butler could mournfully admit in his Advertisement to the "Analogy of Religion": "It has come, I know not how, to be taken for granted by many persons that Christianity is not so much as a subject for inquiry, but

* "Sur l'Existence de Dieu," épître 293 (1771).

that it is now at length discovered to be fictitious."

In the present wonderful century nothing is more wonderful than the progress of science and "the increasing verification of its dicta," and yet eminent men of science, of whom Professor Karl Pearson may be taken as spokesman, tell us that the work of science is not to explain but to describe. Ultimate questions, such as that of Design in Nature, and final causes, he would say, are not for science but for metaphysics, and this with no slight scorn.* Now if men with a subject so noble as that of science for their life-work are content with the rank of hewers of wood and drawers of water, and strenuously claim it, none need complain. The more recent experience of Western nations seems to show that the discoveries of scientific men are destined to raise more and more the standard of the comfort of the human race ; to increase the efficiency of the methods by which the stronger and abler may dispossess and eliminate the weaker races ; to cultivate yet further the intellectual

* "Grammar of Science," xx. xxi. 474.

powers of man. Sir Michael Foster at Dover recently claimed that the moral influences of science are not less marked than her material benefits, and indeed that to the many who are saying "Who will show us any good?" Science has a sure message of hope. It may be doubted whether the morals of man will be higher when science shall regulate them, and the "laws of comfort" become the "laws of conduct." But if only the material and intellectual improvement of man through science be what it is fair to expect, the rôle of science will be noble still. Nevertheless such an everlasting question as that of Design in Nature cannot be set aside by men of science, either because they are too busy to give heed to it, or because it lies outside their special department of science. There are, indeed, such men to be reckoned with as the philosophers, or critics of the sciences, and these have ever been among the best informed men of their time, men to whom special scientists must listen. At the present time in England, Mr. Herbert Spencer is no doubt the most popular of philosophers past or present, and his learned "Synthetic Philosophy," now completed, is to multitudes the end of controversy. It is needless to point out how this compendium of evolutionary thought excludes anything like Design in Nature while an unknowable first cause is admitted. In this lies the completely unsatisfying effect which Mr. Spencer's philosophy produces upon the minds of those who cannot be content to be told *how* things happen, or how scientific men of the present day think they happen, but must continually be "crying for the light" as to the *why* and *wherefore* of their life. To them Mr. Spencer's great system is as disappointing as a lay-figure, marvellously draped according to the most authoritative fashion of the day, would be to an artist. They want something more than "magic-lantern pictures with nothing behind the pictures."

Being the last word of the Agnostic evolutionist, Mr. Spencer's system has the great merit of showing his followers clearly where they should look, and where they should not look for guidance. To those who do not follow it, the value is not less in view of the confidence they may with reason feel as to the refutation of Mr. Spencer's philosophy in due course. Considering the history of philosophy in the past, it is hardly possible to expect anything else. The remark of Mr. Mallock: "Nothing gives to truth so keen and clear an outline as the refuted errors of really powerful thinkers," * in connection with Mr. Spencer's sociology, bears closely upon this. Any person who makes some acquaintance with Mr. Spencer's teachings very soon finds him proclaiming that God, or the First Cause, is unknowable—*e.g.* he speaks of "this deepest, widest and most certain of all facts—that the Power which the universe manifests to us is utterly inscrutable." † Here is the Key of Knowledge peremptorily taken away from those who would follow the leading philosopher of the day. It was all very well to put into the mouth of a great Oxford sage the words: "What I do not know is not knowledge," but a more open mind would well befit a

* "Aristocracy and Evolution," p. 340.

† "The Epitome of the Synthetic Philosophy of Herbert Spencer," p. 7.

man so great as Mr. Spencer on a subject so abstruse. More especially is this the case when it is remembered that he claims to know certain very fundamental matters relating to that First Cause or Inscrutable Power. Thus Mr. Lilly points out that "Mr. Spencer predicates of the Ultimate Reality not only being, but causal energy, eternity, omnipotence;" * four such attributes predicated of the "Unknowable" are a fair beginning of knowledge, one would think! If it be declared that this Power is manifested to us through the orderly phenomena of the universe, interpretable in some measure by our minds, it is going very near to admitting the existence of a Divine being Whom we may in growing measure comprehend. Such a position is the less open to attack when allied with the most profound argument for a Personal God, in the person and work of Him who was "the express image of His person" and by whom He spoke in these last days; and who dared to say: "If ye had known Me, ye should have known My Father also: and

* "The Enigma of Life," p. 226.

from henceforth ye know Him and have seen Him." *

In all the inquiries concerning Design, the question of the existence of a Personal God is involved. That this is one of supreme importance is shown by the ever-recurring affirmations and denials of Theism which appear throughout the history of human thought, and it has given occasion for the acutest intellects of all ages to employ their powers. In the Agnostic philosophy a great First Cause, Inscrutable Power or Infinite Reality is a mere abstraction, necessary for ceremonial purposes, but no more. We may remember how in early Frankish history many of the Merovingian kings nominally reigned and enjoyed the glory of their rank, but in reality their power was wielded by some masterful Mayor of the Palace, and how in course of time their decrepit race gave place to one such as Pippin of Heristal, who could both reign and govern. If one may compare small things with great, this is much the position in the universe which Agnostic philosophy accords

* St. John xiv. 7.

on the one hand to the First Cause and on the other to Natural Selection and other factors of evolution, organic and inorganic. When such relative positions are followed out to their true issue, the final result to the conception of a First Cause among the more ardent followers of this philosophy is not far removed from that which befel the Merovingian dynasty. It is quite clear that if there be no personal God, if the believers in Theism of all ages and all races have been simply personifying out of their own thoughts this First Cause, which prevailing philosophy has shorn of its early glories, there need be no further search after Design in Nature. On the other hand, if the marks of Mind be ineffaceably stamped upon the pages of Nature's story, whatever methods thereof the scrutiny of science may discover, the correlative conception of a personal God is not to be gainsaid.

In the last century, Kant performed a real service to truth in showing that the three time-honoured proofs—ontological, cosmological, teleological, as the schoolmen called them—failed to demonstrate the existence of

God. It seems strange that some eighteen hundred years of controversy and exploded errors should have been needed before a great mind could arise to show the deep truth proclaimed by St. Paul to the Greeks of his day : "In the wisdom of God, the world by wisdom knew not God." * St. Paul himself indeed could hardly have better summed up the arguments for the existence of God than did Kant in his memorable saying : "The starry heaven above me and the moral law within me," and the great philosopher pursuing other methods than those of St. Paul could but arrive at the same conclusion.

In spite of Kant's destructive work towards these three "proofs" of Theism the value of each in its province remains to this day, and their cumulative value is very great, especially when linked with that moral law to which man's nature testifies. Each brings its tribute of praise to the great world-builder and proclaims, "He that built all things is God." It is the familiar Argument from Design to which the succeeding pages

* 1 Cor. i. 21.

will be devoted, with the hope of showing that the evidences for Plan and Purpose in the story of our planet still bear their worthy part, even if candour compel us to admit, "Lo! these are but the outskirts of His ways: and how small a whisper do we hear of Him!"

CHAPTER I

PROVISION OF ENVIRONMENTS FOR ORGANISMS

SINCE the rise of modern evolutionary doctrines the older conception of Design in Nature has been merged into that of "Adaptation." It is needless to do more than point out that the primary meaning of this word has been expunged for the same reason that the older word "Design" has been disused, so that the connotation of Mind and Will may be eliminated from a term bound up with modern biology. It is a term as necessary to the evolutionist, such as Professor Henslow, who scouts the doctrine of Natural Selection, as to the large majority of evolutionists who treat that doctrine as an almost completed induction. Let any scientific man venture, as did Professor Schiller,* to attempt the reconciliation

* *Contemporary Review*, June 1897.

of Design with the theory of evolution, and he will probably meet with a similar reception, a reception which consisted of no notice, as far as I could learn, from any scientist of note, and on the part of Mr. Perry Coste * a trenchant attack, the nature of which may be gathered from the following quotation : "In other words he proposes, by the help of evolution, to save divine morality at the expense of divine power ; his directing Intelligence being not an omnipotent fiend, but only an unpractised though well-meaning bungler. I hope that the theologians will be duly grateful to their very candid friend."

We have then to do the best we can with the conception of adaptation, which happily admits of, though it does not compel, that of Design, for which a plea is being here put forward.

"Everything is adapted in animate nature, and has been from the first beginnings of life," † is a pithy statement of Weismann, which would do credit to a Paley

* *Natural Science*, 1897, p. 414.

† "Germinal Selection," p. 42.

Bell, Chalmers or Whewell. It will hardly be worth while for any to dispute this pregnant saying, so nearly universal is its truth, in general and in particular, extending from a microscopic organism up to man. But that will, purpose or mind is concerned in this adaptation is loudly denied by men of great learning. At the present time the "mechanical" theories of the origin of the universe and its contents hardly hold the field as they appeared to do a few years ago, yet we are scarcely nearer to general acceptance of the conception of Design. The adaptedness of organisms for their life is a large province of the territory of botanists and zoologists, and is one which they are cultivating with marvellous accuracy, ability and zeal. Some idea of the greatness of this biological territory is conveyed when we are told that the harvest of the *Challenger* Expedition of 1872 brought to Professor Haeckel alone 3500 species of Radiolaria and ten years of study thereof!

But with all their ability, zeal and well-merited success, what are botanists, and what are zoologists, or even geologists, chemists and physicists, but expert witnesses in their own department? Judges of the question of Design they are not. Were M. Bertillon and M. Gobert judges at Rennes on a notable occasion? Experts must, or may, come forward in open court with their facts, results, experiments, inductions, and even laws, and are always heard with the respect due to their talents and integrity, but having been heard they must return to the museum, the field, the sea, the laboratory; while the philosopher, if he can, pronounces judgment upon their many voiced testimony as to its bearing upon the larger issue, that "far off divine event to which the whole creation moves."

That the face of Nature bears the stamp of Design is the *quod semper quod ubique quod ab omnibus* which scientific workers would do wisely to acknowledge. Such an acknowledgment, instead of belittling, would confer a dignity and a coherence, a *rationale*, upon their work. This view alone saves them from the inevitable fear that their whole life-work will some day be put to confusion. There would remain for them the worthy task of finding out the modes in which this Design has been carried out. Darwin's discoveries, which at first logically involved Design of some kind by reason of his assumed primordial forms of life, are supposed to have given the *coup de grace* to the older views of this question. Huxley was prepared to admit that a teleology wider than that of Paley was possible. But the veiled teleology of Darwin or Huxley does not suit the doctrine of evolution as "rightly conceived," and strongly maintained by Mr. Spencer and others.

As to the myriad adaptations of means to ends found in nature, they are very generally attributed to a law not less mechanical than that of gravitation. All the structures and parts of plants and animals are supposed to exist only by reason of their value in the struggle for existence to their possessors, or as survivals of some that were of use to remote ancestors. At this amazing position stands the evolutionary Luther with his modern " Here I am, I can do no otherwise." One of its most fearless champions stated it clearly enough in his earlier days when speaking of this "mechanical theory":* "It endeavours to comprise all the facts of adaptation in organic nature under the same category of explanation as those which occur in inorganic nature; that is to say, under the category of physical, or ascertainable, causation. Indeed, unless the theory has succeeded in doing this, it has not succeeded in doing anything—beyond making a great noise in the world. If Mr. Darwin has not discovered a new mechanical cause in the selection principle, his labour has been worse than in vain." In this there is of course exaggeration. Apart from the great revolution which he set on foot, the by-products of Darwin's work have been of imperishable value and wide interest, and his central theory has at least set in motion a host of workers in biology. But when this gifted disciple of Darwin went further still and said that "Science had rendered impossible the appearance in literature of any future Paley, Bell, or Chalmers," he failed to see that every evolutionist of them all is a Paley, Bell, or Chalmers *malgré lui*.

* Romanes: "Darwin and after Darwin," pt. i. p. 402.

PROVISION OF ENVIRONMENTS

Enough has been said to show that the *adaptedness of organisms for their life* is very largely claimed to be independent of Design. But what of the *adaptedness of their environments provided for organisms?* Weismann's statement as to the adaptedness of organisms may well be transposed and remain equally true: "Inanimate nature is adapted for animate nature and has been from the first beginnings of life." It argues a very narrow view of the scheme of things in which we find ourselves, to look only at the familiar side of adaptation, and not to correlate with it the orderly history of the preparations made for us and other living things. The co-ordinated production of environments and organisms, mutually adapted, is a spectacle which might well puzzle the Agnostic evolutionist.

An illustration may here be useful to condense the point before us.

A mammalian embryo undergoes in the early period of its life-history processes called karyokinesis, segmentation, gastrulation, formation of blastoderm with primitive entoderm and ectoderm, and others which need not be specified. Then further differentiation of its cells into organ after organ takes place. It becomes attached to the protecting and nourishing maternal walls. Expansion of these and enlargement of vessels, which are eventually massed together for the placenta, takes place. At this period the growing embryo requires a change in its environment, though it must still be attached to the maternal surface. A group of vessels, intertwined with fibrous tissue, becomes the placenta, a cord containing an artery and vein supplies a direct communication of its blood with that of the mother, by which means oxygenation of its blood takes place. It is delicate and requires protection. Fluid forms round it. The maternal parts, its temporary habitation, enlarge ; muscular tissue, perhaps dormant for years before, becomes enormously enlarged for *future use*. In due time the need for all these elaborate contrivances comes to an end. Means are ingeniously provided for the extrusion of the embryo when mature, and its new life when born. Such a remarkable process as this, preordained from the moment of fertilisation, in which, strange to say, Huxley with the eyes of his faith could almost, but not quite, see "the Hidden Artist" at work, may be repeated in identical fashion many times in the life of one animal. But these and many other changes in the embryo which have not been referred to, could not proceed beyond a few halting steps were it not for the pre-ordained conditions for its coming life meeting it at every stage of its development. Indeed a most apposite comment upon the cogency of the argument here maintained is supplied by an experience, happily rare, known to medical men as ectopic gestation. Here the embryo is diverted from its suited and preparing abode: it develops up to a certain lamentable degree in its abnormal position, an exile from its home, until a fatal result to mother and embryo is seldom averted, and then only by the exhibition of surgical skill, brilliant among many brilliant triumphs: which may be considered a sad and apt comment upon the interruption of Design on the one hand, and on the other upon the power of mind, albeit a mere human mind.

The length and simplicity of this illustration may be pardoned for the sake of the light thrown by it on one aspect of the evidence for Design in animated nature. Let the Darwinian study his plants and animals, and let him prove to the hilt the necessity of his wider "teleology," and call it what he likes, even to Germinal Selection, though Design so subtle and far-reaching never entered the calculations of the theory of organic evolution. Under whatsoever of the many existing forms it may appear, this theory is compelled to assume the origin from unicellular organisms, or even from non-cellular masses of undifferentiated bioplasm, of all the plants and animals known to-day, ranging from protozoa to man, and from protophyta to oaks. To the ordinary man this is a large order upon his faith. But, to begin with, hundreds of millions of years are granted to the evolutionist, or taken by him, and Mr. Herbert Spencer presents him in his "Synthetic Philosophy" with an analogy which is of a character most compromising to his own views. The words, in connection with our subject of Design, deserve to be written in letters of gold. They are given in the section dealing with the evolution of life,* and this is alleged to be "mentally representable in outline if not in detail," and declared to be "a legitimate symbolic conception." Perhaps so, perhaps not. The illustrative words are, "*If a single cell, under appropriate conditions, becomes a man in the space of a few years,* there can surely be no difficulty in understanding how, *under appropriate conditions,* a cell may in the course of untold millions of years give origin to the human race." (The italics are not in the original). It would be difficult for an opponent of Design in Nature to make a more damaging analogy than meets one in this short sentence, well thought out and expressed, as is everything which Mr. Spencer writes. "Appropriate conditions," indeed ! Why, it is these very "appropriate conditions" which furnish the other side of the argument for Design, which is being here considered, and which, except for a necessity to exclude Design from the side of the organisms, would not be gainsaid. The fundamental difference

* The Epitome of the Synthetic Philosophy, *op. cit.* of Herbert Spencer, sect. 118, p. 109.

between those environments, stable and slowly varying according to well-known definite laws, encountered by a fertilised ovum in its course to adult life, and those encountered by organisms in general, is sufficiently clear. In the case of the latter, the homogeneous marine conditions of pre-Cambrian times, the varied terrestrial and marine "climates" of Devonian and Carboniferous, the more differentiated complex Secondary, the still more elaborate Tertiary, more diverse and difficult, with growing competition for existence, changing climates, Ice Ages, volcanoes, earthquakes, destruction and cultivation at the hand of man—all these, with many more changes of condition which have marked the fitful course of life from Protozoa to Man, in spite of their outward complexity, are clear to the teleologist as evidence for Design in Nature. But he would hardly have looked for such an unintentional admission from analogy as Mr. Herbert Spencer furnishes in his comparison of the "appropriate conditions" of the individual and those of the race. In the case of both individuals and race, the orderly production of environments furnishes a strong proof for Intelligent Design in a world which is "not chaos but cosmos." On the other hand, the pre-ordained direction of development and degree of growth contained in the sealed orders delivered to every embryo embarked upon the troubled sea of life is not less significant of Design. The teleologist cannot but be grateful for such a sentence from such a source. It is needless to say, however, that Mr. Herbert Spencer does not consider Design, as such, worthy of mention in his "Synthetic Philosophy."

Upon this side of the question all one need say is, *Fas est ab hoste doceri.* It is, however, a totally one-sided view of the matter to contemplate *only the adaptation of organisms to environments.* The other side of the question of Adaptation must now be considered.

Environments provided for, and produced as in the case of the embryo just stated, lead the mind to a correspondence growing from the dawn of Creation, under which organisms are adapted to environments and *environments produced for organisms,* and this has proceeded in a majestic, orderly manner. It is a spectacle known only in the present century through the labours of geologists, one which poets, sages, and scientists of old desired to see, but saw it not. Yet for all this interminable progression of nature, which has already required some millions of years for its passing, is ample room allowed, with divine insight, in the first two verses of Genesis. Be it remembered that the age of Moses was one in no way enlightened, but rather darkened by the science of the time, nor was the veil lifted in later days, when Isaiah, with wisdom not his own, summed up in prophetic words some of the results of geological science: "He formed it to be inhabited." In the earliest times it was not enough that the little molten mass which became our planet should cool down to the required temperature for the existence of life. In due course, this relatively small planet which we call "ours" cooled down and solidified, and Lord Kelvin says,* "we may safely conclude that the earth was

* "Annual Address at the Victoria Institute," p. 8 (1897).

certainly not solid 5000 million years ago, and was probably not solid 1000 million years ago." Some approximation to the period of solidification of the crust of the earth is thus afforded by science.

It seems a conclusion of science that the earth was built up of meteorites falling together. All this early earth-making has less interest from our point of view than the endless varied processes which followed. Looking to the cooled earth as a prepared habitation for life, the most obvious necessity after sufficient cooling had taken place was an atmosphere suited to aerial respiration. The temperature of the hot water which formed part of the surface of the globe need not have fallen below 74° C. for the appearance of low plant life, such as Confervae, with thick velvety structure, which Lord Kelvin describes as growing under the hot water flowing out of the earth in Canada, or in the mammoth hot springs. Sunlight was needed and was there in abundance. But the atmosphere needed for higher life had to be produced, and was produced, with its proportions of oxygen, nitrogen, carbon, and watery vapour. The method of its production is a subject for interesting speculation, but cannot pass beyond speculation. Lord Kelvin carefully discusses with his vast knowledge of physics and chemistry the question as to the presence or otherwise of free oxygen in the primitive atmosphere. And though he inclines to the opinion that free oxygen much as we have it now was present in that atmosphere, gives suggestions of value as to the great probability that this free oxygen might have been produced by the vital processes of lowly plants such as Confervae growing in hot water. "We must pause," he concludes, "face to face with the mystery and miracle of the creation of living creatures." *

All the teleologist is immediately concerned with is that the atmosphere suited to animal and vegetable life *did* arrive, with its 2.3 tons of life-giving oxygen to the square metre of the surface of the globe. Thus its life-sustaining power became available for *coming* higher life.

* *Op. cit.* p. 25.

It is of no value to object that the chemical and physical laws which we now know produced both the necessary atmosphere for higher life, and that certain simple physical laws gave rise to the oceans by expression of the vapour of combined hydrogen and oxygen and its subsequent condensation. We are no nearer any explanation of the marvel of it all, that just the right proportions arose in the atmosphere, and that oceans and continents gradually divided the field among them.

At this rudimentary stage in the "development" of life shone forth that Design which was never to be suspended to the present time. The ages before the dawn of life having come to an end, there commenced in Primary, Secondary and Tertiary times, as men call them, the formation of those successive forms of life, vegetable and animal, rising from lower to higher, ever interrelated and inter-dependent, with environments suited to their growing needs. The Primary or Age of Invertebrates found the warm and quiet seas ready for their coming denizens, much as did the mammalian embryo of our illustration find ready a soft, vascular mucous membrane for its quiet habitation and supply. The first of the geological periods of life, called Laurentian, with its two vast lines of evidence for extinct plant and animal life—viz., quantities of *graphite* and *limestone*, exhibits the earliest annals of Invertebrate history, and the immense preparations made for material upon which these earliest organisms must have fed, and with which they constructed their simple skeletons. The prolific outburst of marine invertebrate life in the second or Cambrian times is very remarkable, and still more in the third or Silurian—so much so that in the Silurian all the sub-kingdoms of Invertebrates, whether reckoned as eight or five, were represented.

In the succeeding periods of the history of the globe, called Devonian and Carboniferous, warmth and moisture prevailed extensively, and the making of supplies needed by coming man for his higher development was not neglected. The scene shifted in these ages from the sea to the dry land, from the Devonian age of fishes to the long Carboniferous times. In the latter, marshy ground and peat-beds, formed after slow submergence of the land, teemed with insect and reptile life and luxuriant vegetation. Ferns and club-mosses of vast size lived, died, and decayed into those peat-beds where the coal of various kinds, both in Europe and America, was being laid down for far-future use.

The Secondary Age, the Age of Reptiles, was one of the great prolific periods of life, such as that of the marine invertebrates of Cambrian and Silurian times, or the fishes in Devonian. Here was manifested a remarkable development of land animals and plants with corresponding outburst of marine life; crabs, gigantic sea-lizards, and mollusca, for example, now reached their zenith, with ammonites and belemnites. On land appeared butterflies and various insects, enormous amphibians, true reptiles, huge dinosaurs, crocodiles, winged reptiles, small mammals and a few birds. The earliest leaf-bearing plants also came forth. In this period again, as with the invertebrate fauna of Silurian times, all vertebrates with their five orders were represented. How then were these new denizens, many of them appearing suddenly upon the scene of life, greeted in the home where they found themselves? Warmth, excessive moisture, equability of conditions, were provided for this exuberant vegetable and animal life. Here, as in other times, *scope for expansion* rather than struggle for existence, according to Sir William Dawson, was the order of the day. Increasing definition of land and sea which began in Primary, continued slowly through this Secondary period, and took its more modern form in Tertiary times, and slow development of climatic conditions ensued. During this age the great chalk formations of the world were being laid down in the sea, for immense periods of time, constructed from the minute shells of foraminifera, and the flint from innumerable polycystina, spicules of sponge and diatoms. Wonderfully did these tiny creatures subserve the Design prevailing through all geological time, which could anticipate the day of man's growing ability to make use of these stores of flint and chalk. At the close of this long stretch of time, in which the British seas were warm enough for coral reefs and the Arctic Zone for great reptiles, a period of much greater cold prevailed. At any rate this is presumed as the only known reason for that remarkable extinction of species which took place over the large continents, when the giant forms of the Age of Reptiles largely disappeared. The cold termination of the Secondary period served its purpose in preparing the way for a higher scale of life on land and sea. The birds and mammals, which in Secondary times had been represented in low and less perfect forms, became highly specialised as the great colossi of Saurian type gave way to their nobler if weaker successors, and the Tertiary became the Age of Mammals. The new order of creatures of this important epoch was again gently dealt with by a supreme Intelligence. The fresh outburst of vertebrate life, and forests with large proportion of warm-climate types, were not at once subjected to that severity of condition which closed the Cretaceous period. Again, in the opening eras of the Eocene and in the

Miocene, warmth of climate and much moisture prevailed. Higher life of animal and plant flourished abundantly on the continents, now largely increased in area by elevation since the later Secondary times. The excessive moisture of the latter diminished, specialisation of climate increased, lower temperatures gradually prevailed. Volcanic action, a force which is never a convenient one for strict uniformitarians either in geology or palaeontology to entertain, became remarkably prominent in the middle Tertiary times. In quiet Secondary ages, though existing in all ages, it was little pronounced; but in these Tertiary times it became of immense importance in the making of mountain ranges and valleys. It is difficult to say whether the result of its working upon the face of the earth, or the *restraint* of its power, is the more remarkable. The effects at least were of supreme importance to more specialised groups of inhabitants, and in due time the geography of the earth and sea came slowly to its present limits, and in this result volcanic action found its beneficent purpose.

The important remark of Sir William Dawson, already referred to, must here be borne in mind in the study of environments adapted to coming requirements:* "We also see that, not the adverse conditions of struggle for existence, but the favouring conditions of scope for expansion, were, as might rationally be expected, the accompaniments and secondary causes of new inbursts of life." This principle is seen carried out in the equable and comparatively uniform character of the home into which the earliest marine invertebrates were introduced; in the warm marine environment with teeming supplies of food which greeted the Devonian fishes; in the moist marshy and mild terrestrial climate for the flora of those days; in the restrained action of volcanoes and increasing emergence of land. How suited were such free and luxuriant conditions of life to the marvellous animal and plant forms peculiar to the Secondary period! The value of the Sub-carboniferous period of that era, with its long submergence of the land in shallow water, paving the way for the luxuriant land

* "Modern Ideas of Evolution," p. 118.

vegetation of the Carboniferous period, should be borne in mind, and not less the significant introduction of vast quantities of insects pregnant of benevolence for future plant life, withal unconscious of their honoured position. The two broad facts illustrate our point very clearly. The same principle is seen in the gradual slow changes of climate, the slow emergence and submergence of land.

But equable conditions such as these suited not the prolific outburst of higher life among the more hardy kinds of plants and animals, soon to appear in early Tertiary times. The climate gradually altered from the mildness of Eocene and Miocene times, when palms flourished in Great Britain, and Siberia was a temperate abode much like that of the continent of Europe at the present time, to the gradual cooling of Pliocene climate. Then became defined much as now the frigid and torrid zones. Then arose the mountain chains of California, Mexico, the Rocky Mountains and Alps, Pyrenees and Apennines. Volcanic action extensively prevailed, more especially along the land-borders. The definition of land and sea proceeded till "hitherto shalt thou go, and no further, and here shall thy proud waves be stayed," was the beneficent fiat to the restless ocean in the approaching Age of Man called Quaternary. During the Tertiary period a vast population, largely new to the world, was introduced to this prepared home. Its name, the Age of Mammals, indicates the predominant type, and these were now placental mammals of a higher scale than the marsupials of the Secondary period. Lower vertebrates also of all kinds prevailed in profusion; reptiles, such as crocodiles, lizards, snakes, and turtles; birds such as owls, eagles, cranes, pelicans, ibises; mammals such as the earlier herbivores, tapirs, hogs, rhinoceros, deer, and the supposed ancestors of the horse; carnivores with forms like those of wolves and dogs, greater mammals such as mastodons, elephants, thus representing in earlier forms all the great brutes which in the Quaternary times were to reach their climax. Monkeys appeared in Miocene times so widely as to give occasionally the name "Age of Monkeys" to this period, and a few anthropoid apes, and among plants extensive timber forests.

When the last geological age in which we ourselves are living, was ushered in, the gradual cooling of the Pliocene period culminated in the glacial period of the Quaternary Age. The effects of this time of low temperature with, it is believed, more than one glacial period, were of profound importance. The increasing cold killed off many forms of life unsuited for coming days, and man now entered upon the scene with, for the first time, more difficult environments to test his fitness. Transportation of great masses of rock, grinding of surfaces to gravel and clay, immense action of increasing river-systems took place, all of which led to that valuable mantle of alluvial soils which clothed the earth's surface for the profit of man and his subject creatures. Whether we adopt the extreme views held by some as to the omnipotent action of ice alone, or following Sir Joseph Prestwich, Sir William Dawson, Sir Henry Howorth, see in the immense dispersion of rocks, sifting of gravel into sand

and loam, and deposit of alluvium, the action of a flood or floods by which "the delicate handling of soft fingered water" * served its useful purpose, and which, as many believe, led to the fertility of surface of the earth, and the alluvial richness along valleys, and higher possibilities of cultivation of the soil—whether we look to ice alone or to diluvial action as well—the purposeful results are as plain as need be.

The position here maintained is that the argument from the slow and orderly preparation of the environments for coming life on the globe necessarily implies the existence of Design. The succeeding changes of those environments through the geological ages, ever leading to conditions and potentialities for organic existence, rising, pausing, and ever rising towards those in which human life was possible, is unmistakable in its significance—"evolution," "development," or "creation" apart. Here Design, though infinitely long-drawn, is the only conceivable explanation of things.

It may be objected that it is teleology of a

* "Glacial Nightmare and the Flood."

kind so obscure, so much outside our methods of discovery, as not to be worth the name, when it is claimed that changes of climate, changes of level of the land and sea, destructive, irregular, fitful action of volcanoes, earthquakes, floods, with ceaseless chemical and physical processes, are due to the action of a Designing Mind. But surely a very limited view of the drama of life is his who refuses to all this earth-making and earth-moulding, this production of mountains, valleys and plains, of sea, rivers, and lakes, the conception of Design of a very high order. For example, a parallel may be imagined. Conceive the state of mind of an intelligent countryman of sixty years ago, through whose ancestral fields and hills a railway engineer should be seen moving with the tools of his craft in hand, surveying, taking levels, and making plans. The countryman may have credited the stranger with some vague purpose or other, or perhaps hardly arrived so far in speculation. But when in due time this functionary is followed by others with blasting materials, by the men of spade and pick, and their seemingly destructive work takes shape, the purpose of it all and the connection between the first man and the rough crowd who followed would begin to dawn upon his mind, if still slowly. But when the countryman sees the completed railway line and is himself conveyed thereon at the rate of thirty miles an hour, he must confess that above and behind all this work of years, and behind these engineers, surveyors and navvies, with their mapping, levelling, pulling down of trees, hedges, houses, blasting, digging, and boring, some mind of a different order from any he has hitherto known must have been in operation, a mind which could thus bring order out of seeming chaos. It were easy for us to smile at his early incredulity as to plan and purpose, but we should hardly have much patience with him for persisting in that incredulity when the line was opened. He might have asked for information long before the opening day, and perhaps have received it, but in course of time light has been forced upon him. Now, in this story of the making of our earth, the wisest philosopher was no more enlightened than the countryman as to the railway, until a Hutton, Playfair, or Lyell arose to expound for him some pages, here a little and there a little, of the tangled story of geology. But after that wonderful vista of its past history opened up by these great minds, the philosopher should cease his formerly justifiable scepticism, and reading backward the annals of his prepared home should say, on awaking from sleep, with the fugitive patriarch, "Surely the Lord was in this place, and I knew it not."

A parallel has been drawn, however imperfectly, on the one hand, between the growing ovum with its maternal environments, and on the other the cell supposed to be evolved in the course of millions of years into the human race with its cosmic environments.

It has been seen that there are two sides to the old question, "Has Design ruled in the making of the earth and its inhabitants?"

It is maintained that the evidence from environments long and slowly, but not less surely, provided for the coming forms of life, proves that Design must have been at work all through the geological story.

We have come to this pass, in glancing at the two parallel paths leading on the road to Design, that if we are to look for any law governing the growing adaptedness of environments for organism, it is rather one of death, destruction and decay than of any evolution or life-process such as on their side the organisms require (*cf.* Spencer).

Which of the gods of the evolutionary pantheon shall bring to pass this wondrous cycle of phenomena? Shall it be struggle, survival, heredity, variation, selection? None of these will do. We can but admit that these environments have arrived with a singular opportuneness and persistence! The celebrated definition given by Mr. Spencer of Evolution may fit admirably the development of an embryo, but the more it well defines that well-known process by so much the more does it fall ludicrously short of a definition of the preparation of the home and food for the inhabitants of earth. It very poorly defines isolated acts in that side of the drama of creation, and that is all.

Shall we be tempted for an answer to listen to the expert in geology who shall tell us of the metamorphosis of the primary rocks by heat and pressure, of the mode of formation of the igneous and volcanic rocks, of the action of ice and floods, of the sedimentary rocks littered with, and often composed of, the carcases of bygone generations of beings—Foraminifera, Polycystina, Diatoms, Club-mosses, Ferns, Lycopods, the alluvial richness of drift-deposits, or of vegetable mould formed in later days by "natural" means?

The geologist, or physicist, will give us valuable information as to the "natural laws" created by himself, as Professor Karl Pearson will have it, under which all this earth-making and earth-endowing has been conducted. But when the dissertation is over, we can only say that all this decomposing, destructive, cataclysmic action, disclosed for us by his special skill, looks perilously like the direct reverse of those processes of life referred to, which the evolutionist cosmogony has glorified as effectual in the formation of the world, and the population thereof. That cosmogony requires the strange assumption that, on the one hand, the processes of life and on the other, mainly those of death, are harmoniously combined in the orderly bringing forth of an inhabited world.

CHAPTER II

ADAPTATIONS AMONG PLANTS

THE anatomy and physiology of plants and animals may be studied from the point of view of Design in various ways. We might single out striking instances of contrivance in each great order of living things, which was very much the method of Paley. We might study one highly significant organ as to its anatomy and physiology, which method furnished Sir Charles Bell's great Bridgewater treatise on "The Hand: Its Mechanism and Vital Endowments as evincing Design." We might take representative members of the great groups of living things and analyse separately their leading structures and functions, which would be profitable but lengthy. Or again, we might consider a single primary function and trace how it has been met in plants and animals, asking from time to time how far these means adapted to ends bear out the proposition that Design rules in Nature. The last of these four methods is the one chosen as being the most manageable in a limited space. Of the three fundamental functions of organic existence, Nutrition, Relation and Reproduction, that of Relation in its limited aspect of *protection* seems most simply to lend itself to study from our point of view.

We may take it as an axiom that plants and animals possess protective characters sufficient for the ordinary course of their existence. This is common alike to the upholder and opponent of Design, and falls into line with the great truth taught by Darwin that a struggle for life among the lower, and life with comfort among the higher, organisms is perpetually going on. To say that the fittest among these survives is hardly more than a truism. That each organism has enemies threatening its individual life and reproductive powers is a broad fact which it is necessary to bear in mind. We must take liberties with the term "enemies" if it be made to include all the adverse influences which enter into the environments of plants and animals and which may lead to their extinction. We must reckon among the enemies of plants not only other plants of a stronger growth, and animals, parasitic and others, which devour their various structures, of which locusts may be taken as a familiar example, but also such general conditions as change of level, change of climate, soil, droughts. As to the enemies of animals their name is legion. They have not only the general changed conditions to combat which plants also must meet, but they have rivals without number of their own and other species. The competition for food, and for the opportunity of propagating their kind, is keener or at any rate more dramatic, though perhaps not more real, than that among plants, and keener the higher we go in the zoological scale.

The protective characters of plants will here be considered very shortly, those belonging to animals at greater length. The greater complexity of the animal kingdom and the simple fact that the life of nearly all plants is a stationary one, will justify this arrangement. Plants are not possessed of one great group of protective structures, common to animals of the higher forms—the class of offensive armour. Defensive mechanisms abound in plants, and sorely are they needed, to guard them from the numerous foes which threaten their passive life. The maxim of human society, *Si pacem vis bellum para*, is well borne out by the formidable armoury of the animal world. It is but little applicable to the vegetable world. So good an authority as Sir John Lubbock calculates that there are at least 500,000 species of living plants, and this will give some idea of the multitude of adaptations which might be brought to illustrate the protective characters in the vegetable world. But all the lower plants, Algæ, Fungi, Lichens, Mosses, Ferns, Horsetails, Club-mosses, constituting the three great groups of Thallophytes, with varying but comparatively slight morphological differentiation, Bryophytes with stem and leaves and rudimentary root, Pteridophytes with stem, leaves and roots, may be passed by with mere mention. They are flowerless and do not produce seeds. Such plants have their adequate protection, but being of comparatively simple organisation their needs for protection are less interesting from the point of view of Design. Our illustrations will be taken from the more important group of Phanerogams to which most grasses, palms, herbs, shrubs and trees belong.

The root, or descending axis of the plant, is that portion which seeks as its source of supply the earth, serving at once the valuable functions of supplying water, salts and nitrogenous matter to the plant, and of supporting the more ambitious ascending axis, or stem, in its growth towards the second great base of supply, the air.

The root then protects, by supporting, the whole plant, burrowing into the earth with great variety of shapes and constant growth. To gain a picture of the whole plant we must seek to remember its hidden members, which no more see the light of day than do the foundations of a house. The root may be single or branched, conical or spindle-shaped, or much bulged at the base, and narrowed downwards. It may be fibrous as in grasses and much branched, and besides these forms, has many others which need not be enumerated. Though roots grow chiefly in the soil, some are aquatic, some aerial, and others parasitic. They are furnished at the terminations of the newer rootlets with root-hairs which absorb nutritive material from soil, water or air.

The depth and width to which the roots penetrate is adapted to the size and weight of the plant, so that they may meet with safety the strain to which they are subject from storms of wind. The root itself is not without a strong protective substance called the cortex, and it is formed very much after the manner of the bark of the stem or ascending axis. The stem is the substantial framework of the plant supporting the higher organs, and through the minute vessels of its woody fibre must pass the life-sustaining sap in its ascent from newest rootlet to topmost leaf.

As the root takes its earthward and beneficent course the stem rears itself aloft and seeks the air and sunlight. The woody tissue of the stem, found chiefly in bushes, shrubs and trees, is formed of hardened matter to which the vegetable cells in their death give rise and is deposited in concentric rings. This arrangement is admirable for strength and economy of space, and according to the size and needs of the plant it is more or less dense.

Though the stem is so strong a structure compared with other parts of the plant, it requires protection itself, which it finds in the bark. This is a hard, dry, impervious tissue formed out of the external layers of the wood. It consists of dead tissue outside a layer of living material, the latter being in close connection with the stem and surrounding the stem and all the branches. The varieties of bark in many shrubs and trees will at once suggest themselves to one's mind as indicative of contrivance for special needs, such as oak, elm, plane, beech, horse-chestnut, silver-birch, spanish-chestnut, bramble, hawthorn, ferns, palms, grasses, wheat, bamboo.

The whole aspect of a plant conveys the idea from root to branch of a purpose to be fulfilled. In themselves the root, stem, bark, sap, branches are nothing but stepping-stones to higher things of vegetable life. All is crowned in the leaves, flowers, fruit and seeds, towards which all this elaborate system of contrivances for supply, support, and protection has been leading.

The leaves of a plant present numerous and remarkable varieties of shape, size, texture, smell, taste, colour, and roughness. These vital organs need, and obtain, various kinds of special protection, such as extra thickness of the cuticle, dense impermeable structure, hairs, spines. Their profound importance to the well-being of the organism may best be described by saying that here, in their minute and numerous intercellular spaces, takes place the respiration of the plant. To this manufacturing district has all the sap (water with salts dissolved in it) been brought as raw material. Here through the tiny stomata, the carbon dioxide gas is absorbed and elaborated under the action of sunlight into food-stuff for the whole plant, that gas which our terrestrial atmosphere contains in the proportion of four parts to ten thousand, and which the plant must obtain from the atmosphere, if at all. It is through the upward system of minute vessels in the veins of the leaf that the sap comes to meet the absorbed carbon dioxide, and in these intercellular spaces under the action of chlorophyll that green plants in sunlight elaborate starch and proteid matter for the nutrition of the whole plant. This finished product is again distributed through the downward system of tubes also contained in the veins of the leaf. A simple statement of this kind shows the importance of the protection conferred upon leaves by their harder external covering, and of the stomata. The number of these valuable little mouths for the respiration of the plant is very great, and they have been estimated by botanists among many plants—*e.g.* on the upper surface of the leaf of the vine there are 13,600 to the square inch, none on the under surface ; on the mistletoe 200 on each surface ; on the clove pink 38,500 on each surface. They are more numerous as a rule on the under surfaces, but in the floating leaves of the water lily they are only on the upper surface. In those plants like the cactus which have no foliage leaves they are found on the green succulent stems. Surrounding these small openings are special cells, generally two in number, to each stoma, which are called "guard-cells," and have the purpose of closing or opening the orifices, thus regulating the giving off of moisture from the leaf. The construction of organic matter which goes on in the intercellular spaces of leaves, between the ascending stream of fluid and the absorbed gases from the atmosphere, constitutes a manufacture of far more profound importance to the economy of the globe than all the foundries of Sheffield or the looms of Bradford. Not a furnace of any of the great centres of human industry could ever have been lighted, were it not for the age-long work in the dim past, of these tiny factories of the world. Indeed the vast geological period called Carboniferous owes its fruitful existence to the slow unconscious work of vast club-mosses, tree-ferns and the like, which lived, died, and decayed in that almost interminable age. This was one important service of plant life which subserved the higher possibilities of coming human life.

The flowers and their parts concerned with the prime function of reproduction need hardly be considered in connection with protective characters. A veritable new world was opened in this domain of nature by Sprengel a hundred years ago, and marvellously followed up by Darwin, H. Muller, and Lubbock, with work hardly less important in its way than that of Columbus, Drake, and Cook in theirs. When it became known that the colouring, varied beauties, and scents of flowers were not devised for the gratification of man's senses, nor the nectar specially for the behoof of bees, prevailing views as to the function of flowers underwent a total change. To describe the various adaptations of flowers and their parts to their main function of subserving reproduction would require much space and great knowledge, and it would be outside the scope of this humble consideration of protective characters.

But two structures of the plant remain to be considered as to the protection conferred upon them, the fruit and the seed. The fruit consists of the mature ovary as a rule, and certain other parts of the plant enter into its formation in some cases. The fruit and seed resemble all that have gone before in that they are subservient to the propagation of the individual plant, so that the protection conferred upon them is of a temporary character. The fruit and seed, as such, live but to die, and such protection as they need they have in their thickened envelopes. The gay colour and attractive scent or taste of a fruit are often enough profitable to the plant by its being devoured by insects, birds, or mammals, and the contained seed being thus dispersed. The protective characters exhibited in fruits are immensely numerous and varied, and we have but to think of a few familiar forms of fruit to gain a glimpse of this wealth of contrivance. We may take at random the horse-chestnut, cherry, peach, apple, pine-apple, pea, or any leguminous fruit, acorn, walnut, beech-nut, hawthorn, melon, lemon, orange, poppy, currant, cocoa-nut, date, maple. These various fruits are classed mainly as true fruits and spurious fruits, and are further divided into smaller groups—legumes such as pea, drupes such as plum, capsule such as poppy, berry such as currant, caryopsis such as wheat. In a well-known fruit such as the cherry, peach or plum, the thickened envelope, fleshy substance and hardened covering of the seed or kernel, must be remembered as belonging to the fruit, and all as concerned in the temporary protection of the seed within. There are also great varieties in the methods adopted among various fruits by which their contained seeds are discharged in due time before decay takes place, so that certain fruits are dehiscent and others indehiscent. A familiar instance of the former class is the horse-chestnut, and of the latter the cherry.

The seed is found in flowering plants, and among these there are two great groups, Gymnospermous or naked-seeded plants, such as larches and firs, and Angiospermous plants, whose seeds are enclosed in an ovary. In the latter the greater complexity of protective structures is found. As in the case of the fruit the seed requires its temporary protection, and this is conferred by the thickened outer integument or seed-coat, whose variety will occur to our minds by the enumeration of a few examples of seeds, such as the pea, poppy seed, almond, horse-chestnut, pepper, ivy, mistletoe, walnut, custard apple, lime, grape seed, Brazil nut. Whatever the enveloping fruit may be the seed is attached either by a stalk or directly to it, and the number of seeds contained in each fruit varies from one, as is usual in a horse-chestnut, to the vast number in a single fruit of a poppy. As in the case of the fruit the outer coat of the seed must decay or rupture when the period of germination is over, and the embryo is to live anew. The seed thus requires protection and dispersal, and the latter it obtains in a variety of ways. Some seeds are wind-borne and inconspicuous, and possess contrivances such as delicate hairs attached to them, *e.g.* the thistle, which favour this dispersal. Others being swallowed by animals are thus dispersed, their hardened outer coat serving to protect them meanwhile. Then again other seeds possess burrs for the purpose of adhering to any moving object, and being thus conveyed from the plant to fresh fields and pastures new. A close inspection of such a simple and humble structure as a burr will show under a lens a minute curved hook at the tip of each process, serving very efficiently to attach the seed to any object sufficiently rough. Sir John Lubbock mentions the little Herb Robert which will disperse its seeds by a sudden rupture of the envelope to a distance of twenty-five feet. Other seeds attach themselves to the soil, as the flax, or others to trees, as the mistletoe.

There are certain defensive mechanisms designed for the protection of the plant in general, of which spines or thorns on the one hand and prickles on the other are the commonest. The former are modified branches, the latter only outgrowths of hardened integument, or epidermal tissue.

One might well see within a few yards of one another on any summer day's walk in the country eight of these defensive structures—the thistle with sharp-pointed prickly leaves ; the bramble with strong thorns on the smaller branches, curved backwards ; the wild rose with its special thick-based thorns ; the blackthorn with very strong, long, sharp thorns attached to the small and large twigs ; the hawthorn with its more innocent and shorter thorns ; the gorse with closely-set, long, pointed prickles formed by modified leaves ; the nettle with familiar stinging prickles attached to the edges and surfaces of the leaves, with its highly specialised protective mechanism ; the common sloe with its thorns sharp and strong.

Perhaps the most remarkable plant and the most lavishly provided with defensive mechanism is the so-called Monkey-Puzzle, clothed from stem to smallest branch with thickly-set, powerful prickles on the modified leaves.

CHAPTER III

ADAPTATION AMONG ANIMALS—INVERTEBRATES

THE two most important divisions of the animal kingdom are the Invertebrates and Vertebrates, or Chordates, the former being all the animals which do not possess the special organisation of the Chordates. Of these, the Invertebrates mainly exhibit various forms of exoskeleton, and the Vertebrates of endoskeleton.

The varying modes in which the need for protection has been met among animals, afford contrivances so diverse from one another as the outer thickened and hardened layer of an Amœba, protecting the softer inner parts, to the oil with which a bird preens its feathers for protection against moisture and cold, or the hairy coat of a mammal.

The great group of small creatures named

Protozoa comprises those which have no specialisation of functions for the different cells of their bodies. They may be called "one-celled" by reason of the fact that the protoplasm of which they consist discharges indifferently the functions of *nutrition*, *reproduction*, and *relation*, previously referred to. They thus stand apart from all the other members of the animal kingdom.

The rest are all called Metazoa, and this immense group includes creatures so diverse as a sea-anemone and a man.

The Protozoa, or first group of invertebrates, largely inhabit the sea, or, at any rate, are aquatic in their abode. Their need for protection is therefore slight, and yet, microscopic in size as most of them are, there is in very nearly the lowest, the Amœba, a provision by which the ectosarc, or outer layer of protoplasm, becomes hardened relatively, and serves to protect the inner protoplasm. The ectosarc is prophetic of the infinite variety of contrivances destined to appear in higher members of the kingdom for protection. In somewhat higher Protozoa a substance called "chitin," from the Greek word meaning "coat," is produced on the surface. It is a hard, horny, organic tissue, and enters largely into the protecting structures of the lower animals.

In those tiny creatures called Foraminifera, which show an advance in structure upon Amœbæ, there is, as a rule, a shell, or "test," perforated by minute protrusions of the body-substance, whence their name. These "tests" are of great variety and beauty as, for example, in the Nautiloid Foraminifera, with their microscopic shell fashioned like that of the higher pearly nautilus. Among this order are found the beautiful and ancient Nummulites, with small coin-shaped shells. Some of these have, however, in former geological ages, and even in more recent times, grown to a great size. There are also the minute Globigerina among this order, which go to form by their myriad skeletons the bulk of the chalk-formation of the world. Another division of the Protozoa, called Radiolaria, is full of forms of beauty, with varied contrivances for protection of their minute bodies; so much sothat, as before mentioned, Professor Haeckel identified 3500 species which occupied ten years in their study. The Polycystina show "skeletons" of extreme variety and beauty, though microscopic in size, all marine in their abode, and living at all depths of the ocean. These have largely gone to form the wealth of flint found all over the world. Many very beautiful new forms were brought to the light of day by the dredging and studying of the materials obtained in the famous *Challenger* Expedition, sent out in 1872 by the Government under Sir Wyville Thompson. Among lessons of great importance in many branches of scientific knowledge, the remarkable fact was ascertained that the "ooze" which coats the bottoms of the deepest oceans is composed mainly of the delicate flinty skeletons of these Polycystina, and others allied to them. These have been formed from the silica contained in solution in the sea-water in minute quantities, as the other "skeletons" of the Amœbæ and Foraminifera described have been formed by absorption of calcareous matter from the water. Among this class of animals are found the familiar sun-animalcules, living in fresh water, and possessed of no hard external "test," but of a relatively hard ectosarc to protect the soft endosarc, some few showing siliceous shells; the body of these creatures is about $\frac{1}{1300}$ of an inch in diameter! One of these Radiolarians, called Ziphacantha Murrayana, possesses a more elaborate skeleton, passing through the body of the animal, consisting of delicate spicules arranged in a radiate fashion, with secondary connections, in most exact geometrical order. What on earth (or water) could have enabled this microscopic creature by adaptation to its needs, or any other of the supposed factors of evolution, to construct for itself a skeleton of such surpassing beauty and complexity, at the bottom of the ocean, among conditions of life practically identical with those of its neighbours hardly showing any skeleton, it is difficult to conceive.

The next division in the scale of animal life, among the Zoophytes or Cœlenterates, is that of the sponges. These are a stage beyond the one-celled animals, and here commences the great division of Metazoa, where *tissues* and *organs* begin to appear. The soft body-substance of the sponges is in most cases supported by a framework of horny and flinty material. Some sponges are of fresh water, but most of marine origin; some are calcareous in their skeletons, others siliceous. These different forms of framework all resemble one another in being perforated by openings through which the water percolates, for the purpose of conveying nutritive material to the soft cellular body. We human beings are well aware how valuable a secondary use for our comfort is derived from the skeleton of the horny sponges which are found in the Mediterranean and West Indian Islands, and the immense resistance and elasticity possessed by these "skeletons." One only of the sponges of far-famed beauty need be mentioned in particular — the celebrated Euplectella, or Venus Flower Basket. Here a perfect marvel of delicacy and contrivance is exhibited, after the removal of the soft organic substance of the animal's body, with a complicated framework of spicules of siliceous material arranged in a tube, and interlaced one with the other in exact and perfect order. In this tube the spicules are six-armed, and the rays at right angles to one another, and a shape like that of trellis-work is the result. When young, the skeleton is flexible and soft, but the spicules later become fixed and hardened. Sponges may have done much for the comfort of man in civilised times, but another class of Zoophytes or Cœlenterate, the corals, have gone to form in remote bygone ages great islands and continents, on the East Coast of Africa, the Red Sea, Persian Gulf, Polynesia, the Indian Ocean, and the West Indies. These again show supporting and protecting structures for the soft-bodied polyps, of a very efficient kind, secreted by the bodies of these polyps from the calcareous matter contained in the water. The anatomy of the skeletons of corals is elaborate, and has obtained special terms of description from zoologists. Allied to corals are sea-anemones, which are much less important, and widely distributed, and have no hard supporting skeleton, but an outer hardened covering of chitin in some, and in others, a layer of gelatinous or cartilaginous tissue in the substance of the soft body.

In Echinodermata, such as sea-urchins, star-fishes, sea-lilies, the integument manufactures from the sea water a very hard and varied coat for the soft-bodied animal. The skeleton in nearly all these is well developed, and arranged in extremely symmetrical manner, composed of a series of calcareous plates; and, in many, the test, or exoskeleton, is made up of ten rows of pairs of plates, perforated at the outer edge, to allow of the outward passage of the suckers. On the plates, and attached to them, are moveable spines of varying length and thickness. Thus, with such an exoskeleton and protective spines, even sometimes possessed of a power of stinging so as to inflict painful wounds, the group of sea-urchins, star-fishes, and the like, are well able to take care of themselves. This may agree with the fact that they are of very ancient geological origin, being found first in Palæozoic times.

In star-fishes, the arms, or rays, are composed of a number of small bony plates set in paired rows. Attached to each of these is a smaller plate which carries spines. The entire upper surface is protected by a leathery skin, in which calcareous matter is deposited. In some star-fishes and sea-urchins the spines on the surface have a modification at the extremity which enables them to hold on to neighbouring objects like a pair of pincers ; this is independent of the will of the animal (it was originally thought to be a structure of parasitic nature, thus they were called Pedicellaria), and this prehensile power can be exercised for about two minutes.

The great group of animals called Annulosa comprises in the first place, worms of many forms, spiders, crabs, lobsters, shrimps, and insects of all kinds.

In Worms there are no such spicules forming a skeleton as in the sponges. But protection is given by an outer tough coating in some, in others the same with muscles attached to it. In sedentary Annelids which inhabit the sea, there is a protecting tube, sometimes hardened further by the deposition of calcareous salts, or sand, mud, and other foreign substances. In some, even a *lid* is provided at the opening of this tube, which can be used to close the entrance. In certain worms, Chœtopods, some of the gland cells of the outer skin secrete hard bristles, which assist in protection and locomotion. Besides these, the earth-worm possesses a very abundant shiny secretion on the surface, which assists greatly in its protection.

The great group of Insects derives its name from the portions into which its body is divided. It includes nowadays the great class of animals called Hexapoda, from the six legs possessed by true insects. The body is divided into three clearly defined regions, the head, thorax, and abdomen, and each of these parts is efficiently protected by contrivances of diverse kinds. The antennæ and jaws, borne by the head, each contribute to the protection of the animal, and the simplest example of powerful protection in the case of the jaws is afforded by the powerful mandibles of the stag-beetle, resembling horns in shape. The various appendages of the head are used in different species for different purposes, *e.g.* for mastication, sucking, and piercing. The head is strongly protected by a chitinous covering, as also the thorax, the abdomen being of a softer and more mobile nature.

In addition to the tough tense covering, *e.g.* of a stag-beetle, or the equally tough coating of a flea, there are numerous species with delicate protecting hairs, and there are appendages on the end of the abdominal segment, such as the pincers of an earwig, the sting of a bee or a wasp. The legs are also often armed with long spines, which are of assistance to many species accustomed to bury their victims in the sand, and for the depositing of their eggs. There are also *special protective resemblances* in this order of animals, conferring protection on weaker species resembling in appearance the better protected. There are marvellous cases of *mimicry*, with the same object in view. *Warning colours* and *recognition markings* also come under the heading of protective characters. But the consideration of any details in the case of insects is here impossible, seeing that 250,000 species are calculated to have been described, and that Lord Walsingham considers that only about ten per cent. of existing species have been described! We may simply enumerate some of the better known groups:

Hymenoptera, containing ants, wasps, bees, sawflies.

Diptera, various flies and fleas.

Lepidoptera, butterflies and moths.

Coleoptera, beetles.

Orthoptera, such as dragon flies, May flies, white ants or termites, crickets, grasshoppers, cockroaches, earwigs.

The mere mention of these more or less familiar forms of insect life bring to the mind a perfect wealth of contrivance for protection of the bodies of the animals possessing them.

In the Arthropoda (such as crustacea, spiders, insects), so called because of their jointed limbs, there is instead of the calcareous skeleton of sea-urchins and starfishes, a chitinous one, composed of the horny organic structure known as chitin, secreted by the integument. The parts of this skeleton in a variety of forms of Arthropoda are moved by muscles which lie internal to them, opposed in this respect to those of vertebrate animals in which the parts of the skeletons are moved by muscles lying external to them. The immense variety of forms which this great class of animals exhibits will excite our admiration, as showing the beautiful adaptation of their protecting structures to diverse environments, the hard carapace and armour of the limbs in crabs, lobsters, crayfish, to say nothing of the numerous allied forms, king-crabs, hermit-crabs, barnacles, acorn-shells and shrimps, sand-hoppers, water-fleas among the smaller forms. The power possessed by the young among these Arthropoda, or jointed animals, of shedding their protecting covering during their growth, is Nature's method of dealing with these young and stirring lower animals. The jointed young ones have a simple method of changing their clothes, and just shed their protecting "chiton" when it is too tight, remain quiet and in a temporarily timid state for a few days, no longer indulge in their favourite battles, and devote a little time to the secreting of a new "chiton" from their soft integument. They are then again ready for the struggle of their life, offensive and defensive.

The Arachnida or Spider family, in which hundreds of British forms alone of spiders are known, includes spiders, scorpions, mites, harvest-men, and certain parasites.

In many of these the integument is not hardened for protection, but most of the spiders have soft flexible surfaces on the under part of the body, and harder chitinous covering of the upper part. In the scorpions there is a strong chitinous shell all over the body. In spiders the segments which represent antennæ of insects are very efficient pincers used for prehension, as well as for attack. Scorpions have still more formidable nipping-claws, and they are provided with the power of stinging severely their prey by means of the tail or last joint of their bodies, which are hooked, and have two poison-glands with minute canals opening into the tip.

In this rapid contemplation of protecting structures throughout the main division of the animal kingdom, this group of Arachnida furnishes us with as beautiful and familiar a *protective* structure as any, viz., the spider's web. All the spiders possess spinning-glands, in the form of tubular organs secreting a viscid fluid. This hardens immediately it is exposed to the air. These spinnerets are conical organs, usually six in number, situated at the hinder end of the spider's abdomen. As the secretion passes through the minute ducts which lead from the glands to the surface, it is cast into the silken, delicate thread employed by the spider for the construction of its web. It is thought that the primary use of the silky secretion of the spider was, or is, for the formation of the cocoon, and protection of the young, and of a tent or tubular retreat for the mother and young, and that the better known purposes of the familiar web, viz., that of entrapping small insects for the predaceous spider's own consumption, was a secondary function "evolved" in the course of ages.

The Myriopods, including centipedes and millipedes, have also a chitinous integument, and the body divided into numerous segments, the articulated or jointed limbs also being covered with chitin. Some of them possess glands in the skin which secrete an acrid fluid for protection.

The remaining large group of non-chordate animals is the sub-kingdom of the Mollusca. Here we come on ground more or less familiar to all, and for us the interest centres on the shells which protect almost all of these soft-bodied animals. They are aquatic and terrestrial—at least 50,000 species of the former have been enumerated, and less than half as many of the latter. So great is the importance in this group of the means of protection provided, that the study of the shells alone has given occasion for a learned society, the Malacological, with a special journal devoted to the subject. We can hardly be surprised at the immense interest taken in the Mollusca, in view of their importance to the life of other animals of the sea and land for food, their universal marine distribution at all depths and all regions, and the exceeding variety and beauty of many of the shells. The discovery of new species for study seems endless, and deep-sea dredgings, notably that of the *Challenger* Expedition, never fail to bring to the light of day new forms. The vast majority of Mollusca have shells consisting either of one piece, shaped after diverse patterns, or of two valves, constituting the two main divisions of univalve or gastropod molluscs, and bivalve or lamellibranch molluscs; familiar examples of these two divisions are snails on the one hand, and oysters on the other. The shell is in nearly all composed of calcareous material with a small admixture of animal matter, and is formed by the outer layer of the "mantle" of the animal. It is essential to the life of the animal, and the latter cannot, in the convenient manner described in Crustacean animals, shed its coat and form a fresh one. Injuries to the shell can be repaired, but no new shell has ever been known to have been formed. Of the varieties of shell some are called *porcellaneous* from their dense white structure, some *horny*, some *nacreous* or pearly, such as the "mother-of-pearl" shells, and others *fibrous*. In addition to the ordinary protection conferred upon the soft body of the animal by the hard shell, there is in many a further protection of the shell itself. This overcoat of Molluscan shell is called in scientific language the "periostracum," and is a tough, smooth coating laid over the calcareous surface, efficiently protecting, especially fresh water shells, from the eroding chemical action of the water, in which carbon dioxide gas is dissolved. This gives a beautiful example of the wealth of resource in the power of that Great Architect who built all things, even a Molluscan shell. It only remains to remark upon the exceeding beauty of colouring of many shells. This is due to the presence of certain glands in the mantle of the animal. These colours are most varied, and are found especially in those Mollusca which inhabit the warmer seas. This is remarkably shown in the results of deep-sea dredgings, where there is no light, and an almost freezing temperature, which renders the shells dull in colour.

The shells of Mollusca are not only infinitely varied in colour, from white, red, green, yellow, olive, purple, slate-blue to black, and marked in marvellous symmetry in many cases, but in size they will vary from one-fiftieth part of an inch in diameter to the Giant Clam, Tridacna, which may weigh five hundred pounds. A visit to the Molluscan Gallery of the Natural History Museum, South Kensington, opens an almost inconceivable world of beauty.

The leading forms of shell may be noticed. First the Cephalopods, in which the "arms" are ranged in a series round the head of the animal. These comprise cuttle-fishes, argonauts, pearly nautilus, octopus, and a few more rare living forms. A number of extinct forms, such as ammonites and belemnites, belong to this class. The pearly nautilus is the best known and most beautiful of these shells, and is composed of numerous chambers, about thirty-six on the average, the outermost being the largest, and the abode of the animal itself. These numerous chambers of the shell confer great resisting power to it, suited to its deep-sea habit of life. The Argonanta Argo, or paper nautilus, has a very beautiful chambered shell, but the orginal idea that this shell was the product of another animal, and was used by the Argonaut as a boat in which to swim on the surface of the sea, much as a cuckoo uses the nest of another bird, has been exploded, for it swims near the surface with a portion of the shell above it, and progresses like others of this family of Mollusca. The cuttle-fishes have a dorsal plate or cuttle-bone placed under the skin of the back, protecting the hinder part of the animal against collisions, as it swims backwards. These have the further special protection of an ink-bag, which can be discharged at pleasure with a very disturbing effect upon any pursuing marine enemy, and the brown-coloured material is employed now by artists ; it was also used in classical times as an ink for writing. The cuttle-bone and ink-bag are a somewhat remarkable pair of weapons, shield and sword, to have been invented, in the body of one animal by any number of the factors of organic evolution !

The next large division is that of the Bivalveor Lamellibranch Mollusca, represented by oysters, scallops, cockles, mussels and razor-shells. These have their two " valves," or shells, which lie to the right and left of the animal, and are firmly connected together by a chitinous ligament. This is elastic, and by virtue of the valuable elasticity of this structure, the animal is able without expenditure of force to lie with the valves slightly separated. At the approach of danger the animal can immediately close the valves (as one knows to one's cost in endeavouring to open oysters) by the powerful contraction of a muscle or muscles attached to the shell, so-called "adductor muscles."

The largest division is that of the Gastropod Mollusca. These are represented by such forms as snails, whelks, periwinkles, limpets, cowries, and inhabit fresh-water lakes and rivers, salt water at all levels and regions, and the land. Typical gastropods progress by crawling, but some are free-swimming. Some have an internal skeleton, but most have an external skeleton, and some have none at all, such as slugs. Generally speaking, they are univalves, and have spirally-coiled shells ; of these nearly all are coiled from right to left. The mention of the names of these well-known members of a great class of mollusca is sufficient to show the efficient and varied means of protection conferred on the soft animal within ; we have but to think of our many fruitless attempts in the days of our youth to dislodge a well-grown limpet from its rocky home, to form an idea of the power of the muscle which retains it in contact with the rock, and the efficient unpretending covering, given by its strong little shell, to the animal within.

The remaining group allied to Mollusca are the Molluscoidea, which include brachiopoda and polyzoa, and are not of sufficient interest to detain us here.

CHAPTER IV

ADAPTATIONS AMONG ANIMALS—VERTEBRATES

ALL animals are now classified as Chordate and Non-chordate, the former representing all true Vertebrates and certain Semi-vertebrates, the latter the remaining Invertebrates. For scientific purposes the intermediate groups are marked off from Invertebrates by certain zoological characters, but in this place the more familiar division into Vertebrates and Invertebrates may be usefully employed.

The Semi-vertebrates contain certain groups, not of any intrinsic importance, such as lancelets, sea-squirts, sea-worms of a certain kind, which have been from time to time looked upon as links between the true Vertebrates and highest Invertebrates, though, alas! the true prototype of the Vertebrates is still unfound, but not unsought.

The amphioxus, or lancelet, has been greatly honoured in zoological class-rooms and manuals as this missing prototype of archaic origin, but its reputation is rather waning than waxing, *quâ* missing link.

The sea-squirts are not characterised by any notable means of protection, possessing only a tough, leathery covering, shaped like a bag, whence their name, Tunicates, is derived.

The amphioxus has no vertebral column, but possesses the semi-gelatinous "notochord," enclosed in a fibrous sheath, and it is protected outwardly, much as a worm is, by a hardened integument.

Below the true fishes is a class called cyclostomata, containing chiefly the lampreys and hag fishes, called also marsipobranchii, from their pouched gills. The bodies of these lowly fishes are naked, and the hag fishes have a very special protection conferred upon them by their power of secreting enormous quantities of slimy mucus, which may even be so great as to interfere with the fishing in their neighbourhood.

We may now consider the rising complexity of the means of protection, such as scales, spines, fur, hair, feathers, horns, poison-glands, belonging to all groups of animals, from fishes up to man.

It will be simpler to trace the main structures for protection in each group of Vertebrates, as we pass upwards, taking the five classes—fishes, amphibia, reptiles, birds, and mammals—in ascending scale. We can thus show the varying complexity rising to that of man himself, by which different forms of animal life are adapted to their different environments. Such a review must miss the completeness which would attach to the survey of one structure at a time, such as the vertebrate skeleton in its adaptation to the support and protection of animals, but for the purpose in hand, viz., that of evincing the Design displayed in each group of creatures in their chosen and suited homes, the present plan will serve better.

The class Pisces is divided into five orders :

(1) *Elasmobranchii*, or plate-gilled fish, an ancient order to which many extinct fishes

belonged, and which now includes such as sharks and rays.

(2) *Holocephali*, containing one order, the Chimaera Monstrosa.

(3) *Ganoidei*, or armoured fishes, the great majority of which are extinct.

(4) *Teleostei*, or bony-skeletoned fishes, which includes the bulk of living fishes.

(5) *Dipnoi*, or mud-fishes.

The Design evident in the numerous varieties of protecting structures among this vast collection of aquatic animals, of which there are reckoned to be 9000 species, will best be illustrated if we take first a certain living type of the bony-skeletoned fishes, and then consider sundry striking modifications of these, which have existed in past and present times. The fresh-water perch will serve our purpose. It belongs to a family called the Percidæ, and has such numerous congeners as bass, stickleback, mullet, mackerel. Its exoskeleton consists of *scales*, *teeth*, and *fin-rays*. The scales are of the form called "ctenoid," and consist of plates with a comb-like edge to the hinder margin. Two other forms of scales may be alluded to here, found in other groups of fishes, one of which is called "cycloid," from its circular shape, with concentric markings and even edge to the hinder margin; and the other is called "placoid," being plate-like and irregular, of various sizes, and composed often of structures similar to those of the teeth, viz., dentine and enamel. The teeth of the perch are conical, small and uniform, attached to the jaws, as well as on the surface of the palate. It may be here remarked that in most fishes the teeth can be renewed indefinitely, and an extreme illustration of this power is seen in the formidable armature of the shark, a marvel of skill and contrivance, in which numerous rows of reserve teeth are seen folded back behind those in use.

The fin-rays of the perch are delicate bony rods, supporting the fins, and there are thirteen or fourteen spines in the dorsal fin, two in the anal fin. There is a gill-cover, or "operculum," covering the gill-slits and gill-rays.

The remaining structures are the fins. In the case of the perch there are two dorsal fins, a tail fin, an anal fin, two ventral fins, representing the hinder limbs of other vertebrates, and two pectoral fins, or those representing the fore-limbs.

The skull of a perch is a most complicated structure, containing bones marvellously fitted into one another, and producing the pointed, smooth, tapering outline with which one is familiar in most fishes. In a description of the various bones of the skull of a perch, thirty-seven separate pairs of bones are enumerated.

We have considered very briefly the following structures for protection in a common fish, viz., *scales*, *teeth*, *fins*, *skulls*. At once it is clear that these numerous and diverse structures are delicately contrived for the protection of the animal possessing them. The scales firmly attached in front, and free at the hinder margin, each overlapping the front part of the hinder scale, are eminently calculated to protect the fish in its rapid passage through the water, and to favour that passage. This arrangement of the scales of fishes has been very wisely imitated by man in his arrangement of the tiles, slates, or even thatch applied by him to the roofs of his abodes, with an obvious purpose and advantage, and, in the days of mail-armour, to the protection of his person. Not only are the scales firm and overlapping, but they are exceedingly smooth, and rendered slippery by an abundant mucus-like secretion.

The teeth are so obviously contrived for the purposes of support of life, as well as protection, as to need no further notice.

The fins, with their rays, may be looked upon in two lights in connection with Design—first for locomotion, but secondly for support.

The paired fins represent the limbs of the other vertebrates, and not only "represent" them, as the zoologist delights to call it, but, as one may equally well put it, *they are limbs* of a very efficient form, adapted or contrived for the use of the animal in accordance with its habitat. But in addition to the function of locomotion, the fins subserve the purpose of maintaining the position of the fish. If the pectoral pair of fins be cut off, the fish, instead of remaining in a level position, inclines forward and downwards. If the fins of one side be cut off, the fish falls towards that side. Thus the diverse adaptations to the needs of the creature devised by Omniscient skill are exemplified even in a fish's fin. The rudder-like function, as well as the propelling function of the tail, is obvious, and existed in the far-back geological ages, before Man came on the scene and invented, or probably copied, the pattern of rudders and screws for boat and modern steamship.

The skull of the fish is of great importance in the protection of the delicate organs contained within it. The brain of a fish, though of a low order, requires protection, in its measure, not less than that of man, and it is in the higher fishes powerfully protected by the carefully welded small bones, arranged with infinite precision in the fashion mentioned, with anterior tapering extremity. The advantage of this shape, much like that of the prow of a ship, for rapid and easy progression of the fish through the water, is obvious, and this narrowed anterior portion, wider central body, and lateral compression, with pointed posterior extremity, suggests strongly Design at work in the construction of the living creatures, whose shape, proportions, and contrivances, even to the swim-bladder, give to the mind of man valuable suggestions for the construction of his ships.

The small, numerous *vertebræ*, with their simple ball-and-socket arrangement, narrowing as they approach the tail, and the delicate ribs embedded in the muscles, confer a beautiful degree of flexibility upon the body of the fish, with manifest advantage to it in the struggle for life.

The preceding references to Design in the construction of a fish for its suited abode might be much amplified, but it will be of more interest to look at certain highly specialised modifications of these various protective structures among the great class of fishes. Some of these are most striking, and to our eyes almost grotesque. But manifest advantage to the individual form is conferred by each modification, as will easily be seen.

The scales are much ruder and harder in certain of the more ancient fishes and their diminishing modern representatives, such as the sharks and rays. Some of these possess an exoskeleton of plates formed of a substance like that of teeth or granules; the latter form the well-known article of commerce called "shagreen," or dried skin of the shark.

In the dog-fish the whole of the surface is roughened with numerous pointed projections termed *dermal denticles*, from their close resemblance to teeth. This point is interesting in connection with the fact that the teeth of animals are what is called "dermal" structures, as to origin being developed from the skin-layer of the embryo. This is exemplified in the singular arrangement of teeth, in some fishes attached to the mucous membrane of the mouth, while others are welded to bone, others still more deeply embedded in sockets.

The great basking shark has its whole body covered by these *denticles*, and these constitute very efficient protective armour. It differs from most of the sharks in being harmless if not attacked, though a very formidable creature upon which to make any attempt at capture, as a single blow from its enormous tail is sufficient to stave in the sides of a boat. A specimen of this shark is in the Natural History Museum at Kensington, obtained near Shanklin in the Isle of Wight, and is twenty-eight feet long.

In the spinous shark large scattered tubercles take the place of these small *denticles*, and other fish, again, are marked by a naked or entirely smooth skin. The hag-fishes, for example, have a smooth surface to their bodies, but are able to secrete from certain glands in their skin an immense amount of shiny mucus, which compensates in the matter of protection for the formidable spines, tubercles, and scales of other fishes. This slime serves a useful purpose in their habit of burrowing into the bodies of other fishes, in which they are often found. Another remarkable fish, destitute of protecting scales, is the electric eel, found abundantly in the rivers and lagoons of Brazil and Guiana. It is well known for its possession of a powerful protective structure, serving the purposes of offence and defence, in the shape of two organs near the hinder end of the animal, which can convey a strong electric shock to other creatures. The torpedo also among the electric rays (allied to sharks), possesses a series of galvanic plates, arranged on each side of the median line with great precision, and it is able to stun or kill other animals with the shock of its electric current. It may even injure human beings seriously.

The surface of fishes is characterised by a wonderful variety of colouration, and in many of them this is protective, such as is found in the dull brownish grey and spotted upper surface of flat fish, harmonising with the colour of the bottom of the sea, the under surface of the fish being white. The mackerel, and many other fishes inhabiting the open sea, have the under surface white and the upper dark and beautifully mottled. The colours of fishes are also capable of a rapid change, and are much affected by the temporary brightness or otherwise of their surroundings.

Two specially strange modifications of the scales of fishes may be here alluded to. The coffer fish, or Ostracion, has a curious angular body which is enclosed in a complete cuirass, composed of plates carefully adapted to one another in the form of a mosaic. There are many species of this sub-family in tropical seas. The globe fish is also a remarkable creature, capable of extreme distension of the body with air, which it takes in through the gullet. It is called the "Sea-Hedgehog," and most appropriate does the name appear to the mind of any one who has seen a dried specimen of this prickly fish in the non-inflated and inflated state. In the latter it may be almost globular in shape. The skin has *no scales*, but multitudes of sharp spines, and these are capable of being erected as are the spines of a porcupine. The inflated globular shape also tends to make the spines project at a right angle from the tense skin. The fish in this condition is somewhat helpless, drifting about with its back downwards, but obviously well protected from attack. Even a shark would hesitate to venture on a mouthful so prickly and unmanageable. When it desires to do so, the globe fish can resume its more slender and active condition by expelling the contained air, which it does with a loud hissing noise. It is well matched in the vegetable kingdom by the "monkey puzzle."

A remarkable member of the scaly-finned fishes is one called Chelmon, which has a tube-like muzzle. It frequents the shores of seas and sides of rivers in pursuit of food, and is said by Lyddeker to be able to eject with extreme force and accuracy from its tubular mouth a drop of water, so as to strike at a distance of four or six feet any object, thus capturing any other creature, if small enough, when it falls into the water.

The class of sword fishes is a remarkable group of specialised animals, the well-known weapon of offence being produced by a prolongation of the upper jaw, and it often attains most formidable dimensions. It is a fact worth bearing in mind that this well-armed warrior of the deep *is not otherwise well protected*, having neither scales nor teeth. Its panoply for submarine warfare is more analogous to that of the modern rifleman than of an ancient knight armed *cap-à-pie.* Its one great weapon, from which its name is derived, is able to transfix a cod-fish or tunny, and it can by repeated stabs overcome a whale, and even penetrate the strong timber of ships with its terrible sword. Lyddeker quotes the case of a specimen in the Museum of the College of Surgeons of London, in which the portion of the bow of a South Sea whaler is shown with the end of the sword of a sword-fish embedded in it. At one blow the fish had lunged his sword through and completely transfixed thirteen and a half inches of solid timber ! A case is also shown in the Natural History Museum, South Kensington, of a ship's side penetrated to the depth of twenty-two inches by the sword of one of these fishes. Swords have been obtained from these fishes three feet long, and with a diameter of three inches at the base. They possess a remarkable dorsal fin, and will float at the surface of the water, sailing before the wind like a boat, and are found frequently in tropical and sub-tropical seas.

Another fish with a weapon of offence

somewhat similar to the last, is the saw-fish, and may be mentioned here, though not allied to the sword-fishes in classification. It is one of the sharks and rays, and belongs to the family Pristidæ. Its terrible saw-like weapon is developed from the cartilage of the mouth, and shows a large tapering structure consisting of five portions strongly welded together, and furnished with a double series of lateral teeth embedded in sockets. The length of this saw-fish may be twenty feet, and the saw six feet long, and one foot in width at the base. Saw-fishes, like sharks, have their mouth on the under surface behind the saw, and it is furnished with no needlessly strong teeth. They strike their prey sideways, thus tearing the flesh to pieces, and afterwards devouring it at leisure.

The sucking-fish, of which there are several species, deserves mention for its singular disc on the upper surface of its head. By means of this disc it commonly attaches itself to the bodies of sharks, turtles, ships, or any other suitable moving object, and is thus carried about without exertion on its own part, and furnished with a supply of food as required. It is thus carried to "fresh fields and pastures new," and obtains free quarters and board; indeed, it may be considered one of the few independent gentlemen of the deep. They are said to slide off the body of their host when the latter is caught, and leave him in the lurch. Moseley points out that it is the back of the sucking-fish which is adherent to the body of the shark, and it is *light coloured* instead of dark, and the belly (usually light in colour) is dark-coloured; and he says: "No doubt the object of this arrangement is to render the fish less conspicuous on the brown back of the shark." Lyddeker also remarks upon the sucking-fish: "*It may be mentioned that the development of this disc by means of what is called Natural Selection presents one of the strongest objections to the acceptance of that doctrine, since in its incipient stages such a structure would be utterly useless.*" (Italics not in the original.) This admission is remarkable from a pronounced evolutionist like Mr. Lyddeker, and the same objection is applicable to a very large number of highly specialised animals, such as the electric eel, torpedo, sword-fish, saw-fish, globe-fish, and hosts of other members of the animal kingdom. The electric organ of the torpedo was very powerfully brought forward by the late Duke of Argyll not long ago as a case in which the incipient stage of its formation could not be accounted for by Natural Selection, the currents at first induced being of a character too weak to be of any conceivable value to the possessor in the struggle for existence. This case was allowed by Romanes to be a valid one, but he maintained that it was the only proved case, and that, therefore, *exceptio probat regulam.*

But, if a digression may be permitted, one cannot but ask what value in the struggle for existence can be attached to many a now finished product of the animal kingdom in its early, rudimentary, or incipient stages? Of what possible value could be the minute pimple on the upper jaw of an ancestor of the present sword-fish, which must, on the theory, have preceded the finished product?

And what of the corresponding slight

projection on the upper jaw of a saw-fish, destined *ex hypothesi* to be "evolved" into the formidable serrated weapon described as now existing? Could the singular distensibility of a globe-fish have had any value in this struggle before it "evolved" into the present ingenious contrivance? Or the disc of a sucking-fish? Or the poison in presumably infinitesimal quantities from which the deadly weapon of the cobra must have descended through myriad ancestors? Or the secretion of the skunk, now so powerful that when a cubic centimetre of air contains $\frac{1}{69000000000}$ part of the secretion, it is plainly discernible? Or the tusk of a narwhal, arising like the sword of a sword-fish? These are but a few of the highly specialised structures found throughout the animal kingdom, and which for the imaginary production of them by Natural Selection, *on paper even*, bewilder the human intellect.

Turning from this well-worn by-path of incipient structures and their supposed production by Natural Selection, we may look at a few more remarkable organs of protection in the class of fishes.

The British angler-fish, or sea-devil, may be mentioned as a singular creature possessing fishing-tackle of no ordinary kind. It lives at small depths on the coasts, and exhibits a wonderful degree of protection, as well as provision for its particular needs. Lying at the bottom of the sea, it can move on the surface as if walking, with its pectoral and ventral fins used as limbs, and mostly hidden in seaweed. All round the great head of the fish are fringes, which, with protective colourings as well, constitute efficient defences against most of its foes. But defence is not enough—matters of commissariat must be attended to. So, as Dr. Günther says: "To render the organisation of these creatures perfect in relation to their wants, they are provided with three long filaments, inserted along the middle of the head . . . the filaments most important in the economy of the fishing frogs (as they are called) is the first, which is the longest, terminates in a lappet, and is movable in every direction." He points out how the angler, and many other fishes, uses this filament as a waving bait for other creatures, which are engulfed by the simple act on the part of the angler of opening its gape. This gape is wide, and turned upwards in a striking fashion. Further still, it is found that in some fishing frogs, or anglers, inhabiting deeper parts of the ocean to which no ray of light can penetrate, *the filament is provided at its end with a luminous or phosphorescent organ!* One can imagine these ugly fishes being looked upon much as poachers are among mankind.

The mud skippers, found on the coasts of tropical oceans, have eyes projecting in a singular manner, with outer eyelids, very numerous scales all over the body, and the pectoral fins are muscular at their base. They can, by this means, jump or hop along the mud on shores, and even climb low trees, holding on with their pectoral fins. A special power of moving through grass or underwood is possessed also by the climbing perch.

The gar pike has the upper and lower jaw projected into a long-pointed beak, and can, with these delicate pincers, seize small fish very efficiently.

Flying fish are of many species, and are mostly found in tropical seas. They possess very long and wide pectoral fins, somewhat like wings. Their active aerial flight, taken from the surface of the water, is well known. This power is evidently conferred upon them for the main purpose of their own protection when pursued. Lyddeker says they may fly five hundred feet, their course resembling somewhat the flight of a parachute.

One familiar denizen of our waters is worth notice, more from its specially fierce and voracious character, and formidable little suit of armour, than from its size. The stickleback of our streams and ponds presents a variable number of very sharp and isolated spines on the dorsal, and one on the ventral surface. They have no scales, but large scutes on the sides, forming a coat of mail. They are also interesting on account of the elegant nests constructed by them for their eggs, guarded by the males, and important from their immense number, and their rapacity and strength out of all proportion to their size.

The class of animals known as Amphibia is not of sufficient importance from our present point of view to detain us long, and it will only be necessary to mention a few characteristics of the group, of which frogs, toads or the tailless amphibians, and newts, salamanders, or tailed amphibians, are the chief. Amphibia are mostly destitute of scales and present a moist soft skin, possessing a colourless epidermis, often shed and renewed. They have the power of adaptation of their colouring to their surroundings, and have a further power of protecting themselves by a milky secretion from glands in the skin, which is often highly poisonous and defensive. Their soft skin is also concerned in the function of respiration, and through it they imbibe moisture from the damp surroundings of their abodes, and they thus find it unnecessary to drink. It is a point worth notice that the Amphibia show a decided reduction in the number and efficiency of their teeth, when compared with fishes. This may be looked upon as correlated with the greater development of their fore-limbs for the purpose of prehension, the teeth being rendered less important.

In frogs and newts the toes show small nails, and sometimes adhesive discs on the lower surface. Salamanders and newts mostly spend their life in water, and, being of nocturnal habits and not very conspicuous, possess sufficiently good protection against their enemies. They have also the power of replacing limbs that have been lost. Those that inhabit cold regions are capable of passing through a torpid season, reviving when the warmer weather arrives. Others also inhabiting hot countries are able to remain torpid through the season during which their marshy, moist homes are dried up. Among the salamanders some are brightly spotted, and the smooth shining skin secretes a sticky poisonous fluïd, which confers good protection upon its possessor.

Reptiles constitute the third great class of Chordate animals, numbering some 4000 species, and include crocodiles, tortoises, turtles, snakes and lizards. Most reptiles, excepting tortoises and turtles, are elongated in form, have a somewhat long tail, and are mostly provided with two pairs of limbs. Snakes, however, are destitute of limbs, except in the case of two species, tortrix and python, possessed of aborted hind-limbs.

Crocodiles show the familiar hard horny appendages to the skin, in the form of plates arranged close to one another in rows resembling ancient armour, which are shown in all the regions most liable to injury, such as the back and tail. They are adapted both for life on land and in the water, and unable to remain long under water. In accordance with their frequent habit of lying near the surface of water, they possess a remarkable arrangement of the posterior openings of the nasal passages. These open as far back as possible in the cavity of the mouth, just within a short distance of the upper opening of the windpipe, and this arrangement allows of the unusual power of taking air into the lungs when the anterior portion of the cavity of the great mouth is full of water, the external opening of the nostrils being placed at the very end of the snout, and remaining barely visible above water. This constitutes a very efficient method of protection from foes and concealment from prey. The great rows of teeth and deeply-set eyes and small external ears with their covering for protection, need only to be mentioned in the list of the armour, offensive and defensive, of the various crocodiles and alligators found in the sub-tropical and tropical regions of the world.

Tortoises and turtles possess the well-known exoskeleton or shell, and this constitutes their first line of defence. Their second is that of the horny toothless beak. As their protective structures are almost entirely passive, and the form, texture, and arrangement of their carapace or shell is so familiar as not to need description here, it is sufficient to say that the strong hard substance of the plates, their firm articulation, the carefully convex shape of the whole, and the power possessed by many of the tortoises of withdrawing their head and limbs within the shelter of their movable castle, convey a high degree of protection against other than human foes. Indeed one is not surprised at those practical old soldiers of Rome having invented or imitated the moving fort or *testudo*, on the lines of this arrangement of the protective structure of these reptiles.

Snakes present three main structures of a protective kind—scales, developed on the integument, with which one must remember their remarkable power of frequently changing their skin; protective colouration; and among venomous snakes the poison-fang and gland, with the muscular apparatus for ejecting a stream of the venom along the grooved fang placed in the front of the upper jaw. Time will not allow of any details being given. With these protective arrangements and their power of rapid sinuous movements, snakes are not less equipped for the struggle of their life than other animals. The reserve fully-developed poison-fang behind the one in use needs to be remembered. Indeed, it has been noticed that, considering the fact that non-venomous and venomous snakes get on equally well in life, the latter may be called over-equipped animals. The eyes of the snakes are protected by a thin transparent layer of skin for protection of this delicate organ, and this layer is shed with the rest of the skin and renewed.

Lizards, inhabiting the land mainly, some trees and some the water, are a large group of animals protected mainly by their colouring, active movements and scaly skin. A few have a poisonous bite, but most of them are harmless. The most interesting from the present point of view are the chameleons, very sluggish, harmless creatures, mostly arboreal, but remarkably protected by their power of changing colour, not only according to their surroundings, but from yellow at night to dark green at dawn, and brighter in colour as the daylight increases. They have a singular thin tongue, several inches long, which can be protruded with lightning-like speed towards any small prey, which the sticky bulbous end captures with unerring skill, while the creature itself may be solemnly seated on a bough, apparently as motionless as the bough itself, with only its globular eye revolving in a weird manner. Lyddeker points out how utterly defenceless are these creatures apart from these characters mentioned.

Birds form the next class of the animal kingdom, and one which serves admirably to illustrate the design apparent in all classes, but in none more than this familiar group of animals. Though clearly defined, the class Aves is a very large one, more than 10,000 species being enumerated.

Birds are separated from all other Vertebrates very sharply by the possession of feathers, and it would be difficult to place any specimen of this class in any other than its true zoological position. It is, indeed, almost certain from evidence of fossil birds that the extinct forms also possessed feathers.

In many of their characteristics birds resemble very different groups of animals—*e.g.* they possess a four-chambered heart and warm blood, and so far resemble mammals; they lay eggs, and produce their young directly from eggs, and thus resemble lower Vertebrates. They possess the usual four limbs, the two anterior limbs being used as a rule for flight, the two posterior for walking or swimming. In this arrangement of two pairs of limbs they resemble nearly all Vertebrates. It may be noted here that birds have a larger range as to their mode of progression than any class, being adapted for flight, for swimming and diving, and for walking or running. They thus inhabit largely the air, less the water, and still less the land. Among mammals the range is smaller, inasmuch as the few mammals that can fly—bats, squirrels, and phalangers—do not possess their organs for flight in a highly-developed form.

The structures in birds concerned in their *protection* are very remarkable, and differ much from those of any other class of animals. The most characteristic are feathers, possessed indeed by no other class. They are epidermal structures, analogous to scales of fishes or of reptiles, and to the hair of mammals. They serve most beautifully and manifestly the purpose of protection. It is clear that there are two important purposes in the clothing of a bird with feathers. On the one hand, the feathers are most valuable non-conductors, with the important effect of maintaining the temperature of the bird's blood in the course of its rapid flight through the cold air. The feathers being so closely set together, and in different layers, one can see how a considerable bulk of warm air is retained round the main organs and parts of the body. On the other hand, the feathers, themselves very light, also assist materially in lessening the specific gravity of the body by retaining a certain amount of air, and thus serving a purpose, in a more delicate manner, that the swim-bladder of the fish does in its watery environment.

A feather consists of numerous parts, which have received different names. First, there is the main shaft, divided into the quill, and a solid portion called the rachis, which is square in section. These parts need no further description, being so well known. The rachis gives off a number of processes called barbs. The quill is embedded in a pit in the epidermis, and is hollow, with an opening at the proximal end, and a second opening at the junction of the quill with the rachis. Here it should be observed how delicate is the contrivance by which the tough, light, quill-structure is filled with air, and the minute provision made in the opening at the distal end called the "superior umbilicus," by which the contained air communicates with the outer air, thus preserving the proper degree of air-pressure within the hollow quill. The barbs are attached by their bases to the borders of the rachis, and are interlocked one with another by the delicate contrivance of barbules, consisting of flattened plate-like structures, held together by fine hooklets. These together constitute the vane of the feather, and the whole mechanism, when carefully scrutinised, even to the minute hooklets locking together the barbules tightly and accurately, testifies to a very great degree of skill, intelligence, and will in the production of a structure so light, so strong, so firm to resist external pressure, so protective against heat, cold, and moisture, as the commonest wing-feathers of a common bird.

The distribution of feathers is admirably adapted to a maximum of protection, warmth, lightness and smoothness of contour, and a minimum of waste of tissue and size. The quills form the large wing and tail feathers, called the remiges and rectrices. Of the former there are three main divisions according as they are attached to different bones, and are called primaries, secondaries, humerals. The coverts or textrices, are short feathers clothing the general surface of the body. Here the barbules need not be so closely interlocked, and they are not so, being easily detached from one another. A small patch of feathers, directed backwards, covers the external ear in most birds. There are also filoplumes, or rudimentary feathers left in the skin after the others have been removed.

The down feathers, or plumulæ, are numerous, small, delicate feathers, with soft barbs, separate from one another, all over the spaces between the rest of the feathers. There are also scales on the toes, and, as a rule, no feathers, and the toes are provided with claws.

In connection with the feathers of a bird, one must not omit to notice the remarkable oil-gland, which is found most developed in aquatic birds. It is hard to imagine anything more significant of Design in the efficient protection of the feathers and body of an aquatic bird than this receptacle, placed in a convenient situation for the bird to reach it with its beak. The small sac referred to lies in a sheltered, convenient position on either side near the tail of the bird, and so placed it is well protected from pressure, and yields, when squeezed by the beak, a thick oily secretion, wherewith the bird "preens" its feathers, conferring on them the necessary amount of "waterproofing," renewable as required when the bird's sensations inform it of the need. Such a "waterproof" would put all our mackintosh makers to shame! Paley's remark upon this oil sac is: "Nothing similar to it is found in unfeathered animals. What blind *conatus* of nature should produce it in birds, should not produce it in beasts?" Weismann would have a ready answer, "Oh, because everything is adapted in animate nature!"—which is only his theoretical way of forcing into a mechanical law all questions of ultimate causation—*e.g.* in the case before us, which any one but an evolutionist committed to a theory could not but answer, "Surely, Mind, Will, and Design has done it." But most of such answers as Darwin, Weismann, and other great teachers give to the ultimate questions of nature are nothing more than "making windows which shut out the light, and passages which lead to nothing." No doubt the "windows" are skilfully devised, artistic, often beautiful, but for the transmission of the light of heaven they avail not.

The only further matter to notice in regard to the feathers of birds is the remarkable power by which, twice a year, or at least once, all birds change their plumage. This enables the plumage to be kept in good condition. Lyddeker refers to the case of the duck, of which he says that the moulting, instead of being gradual, as in most birds, is carried out so rapidly that all the wing-feathers are shed simultaneously. This becomes possible because the duck, being able to hide itself among water-plants, is thereby not at a disadvantage among its foes for lack of the wing feathers during the moult.

A very characteristic means of protection conferred upon birds consists in the air-spaces which extend as prolongations from the air-passages through the other organs, especially near the spine, and even into the bones. By this means the bird is able to take into its body a large bulk of air. Professor Jeffrey Bell quotes experiments by M. Bert, showing that a bird can take in one-sixth part of the whole bulk of its body in the form of air, and that by the large amount of air thus taken in, the specific gravity of a bird's body is reduced from 1.3 to 1.12, a diminution in weight of obvious advantage in its rapid aerial flight. In addition to this lighter condition of the whole body, the air taken into the organs and bones serves admirably to warm the air of respiration, as it is rapidly inspired in the cold atmosphere. Acting thus as a reserve warm chamber, and mingling with the cold air, it serves also to keep up the warmth of the bird's blood. Here, again, is an admirable arrangement by which the bodies of birds have numerous air-sacs besides the lungs, (nine of which are enumerated), and the bones are hollow, communicating by foramina with the warm air of the lungs, rather than containing marrow as in terrestrial and aquatic animals. All these contrivances render the body generally light, and in no way interfere with its strength. It may be mentioned also that the young of birds do not possess pneumatic spaces in their bones, but marrow. The pneumatic spaces of flying birds are not entirely correlated with their power of flight. Exceptions to what one would suppose to be the rule occur—*e.g.* the swift has its bones nearly solid, and yet has a rapid flight; the pelican, gannet, hornbill, larger birds and poor fliers, have their pneumatic spaces developed to a great extent. The penguins, however, *which do not fly*, show more exact adaptation to their life, as they have solid bones containing marrow. In the ostrich and similar birds, the "pneumaticity" is greatly diminished, but not absent from some of the bones. The *beak* of birds takes the place of teeth in other vertebrates, no existing birds possessing teeth. It consists of an upper and lower structure, and the great variety of form and size, so well known to us, indicates the different uses to which they are put in the struggle for life.

The skull of birds protects the brain very efficiently, being beautifully firm, though lightened by air spaces in many species, the numerous bones composing it being welded together without the sutures usual in other animals, which in the case of birds disappear as growth proceeds.

The nasal apertures are protected by being placed far back on the skull, with obvious advantage to the bird in its rapid flight through the cold air.

The external ear, as has been said, is carefully protected by a tuft of feather surrounding it.

The eye, again, has its special protection of a third eyelid, in addition to the usual two lids. It is called the "nictitating membrane," and is highly developed in birds and fishes, being of manifest value in protecting the eyeballs of these two rapidly-moving creatures against the impact of foreign bodies in water and air. Depending less upon hearing than many other Vertebrates for their protection, and very greatly upon their power of sight, it is of the utmost importance to birds that their eyes should be both highly developed—which they are in all birds—and well protected, which they are most efficiently by this third eyelid. It is a translucent, glistening membrane, capable of being moved rapidly over the surface of the eyeball, and serves in the most beautiful manner to lubricate and cleanse the surface. This membrane, so highly developed in fishes and birds, is a source of joy to the evolutionist tree-builder, for he finds what he calls a "vestige" of it in man's eye, and points to the latter as a proof of man's bestial descent. It is in man a small fold of mucous membrane at the inner corner of the eye, and serves in him the simple but important purpose of protecting the deeply-set inner corner from the intrusion of foreign bodies. Man does not need the same highly specialised *membrana nictitans*, but he does need what he has got, and it is idle to call the structure in question "vestigial" because it is not of as much use to him as the third eyelid is to a bird.

It remains only to notice the chief orders among this great class of birds, and the division given by Lyddeker, a modification of that by Dr. Sclater, is suitable for the purpose. There are twenty-five orders given, and the names of most of them will convey to the mind the outlines of the functions and structure of each order :

1. *Passeres*, or Perching Birds.

2. *Picariæ*—Woodpeckers, Cuckoos, Hornbills.

3. *Psittaci*—Parrots.

4. *Striges*—Owls.

5. *Pandiones*—Ospreys.

6. *Accipitres*—Eagles, Falcons, Vultures.

7. *Steganopodes* — Pelicans, Cormorants, Gannets.

8. *Herodiones*—Storks, Herons.

9. *Odontoglossi*—Flamingoes.

10. *Anseres*—Ducks, Geese, Swans.

11. *Palamedeæ*—Screamers.

12. *Columbæ* — Pigeons, Dodo, Sand-Grouse.

13. *Gallinæ*—Fowls and Game Birds.

14. *Fulicariæ*—Rails and Coots.

15. *Alectorides*—Cranes and Bustards.

16. *Limicolæ*—Plovers, Curlews, Snipe.

17. *Gaviæ*—Gulls and Terns.

18. *Tubinares*—Albatrosses, Petrels.

19. *Pygopodes*—Divers, Auks, Grebes.
20. *Impennes*—Penguins.
21. *Odontornithes*—Extinct Toothed Birds.
22. *Crypturi*—Tinamus.
23. *Stereornithes* — Extinct Patagonian. Flightless Birds.
24. *Ratitæ*—Ostriches, Emus, Cassowaris.
25. *Saururæ*—Extinct Long-tailed Birds.

The main protecting structures of birds as a class have now been shortly described, and one may again ask with astonishment how this complicated system of contrivances could have been "evolved" in the course of even millions of years, because of a supposed need for the bird family to exist, multiply, struggle, and, as it were, invent for themselves a combination of contrivances so admirable. There really is and was no need for all this apart from Divine plan and purpose in Nature.

Among the great class of Mammalia those characters conferred upon them for protection present to us a broad fact which touches closely the matter of adaptation. This class includes animals of a higher organisation in almost all respects than those that have preceded. Of these the most important is *higher cephalisation* or increasing proportion of the size and complexity of the brain. In lower levels of life there are some remarkable exceptions to this broad rule—*e.g.* among insects the brain of an ant so impressed Darwin as to cause him to say,* "Thus the wonderfully diversified instincts, mental powers and affections of ants are notorious, yet their cerebral ganglia are not so large as the quarter of a pin's head. Under this point of view, the brain of an ant is one of the most marvellous atoms in the world, perhaps more so than the brain of a man." But, broadly speaking, ascending brain-power shown not only by proportional weight and size of brain, but by complexity as well, marks all the Vertebrate or Chordate classes, especially Mammalia.

The striking fact in regard to characters for protection is the diminishing extent and complexity of "passive" structures, correlated with the increasing power, through higher intelligences, of employing the "active" characters subserving protection.

* "Descent of Man," i. p. 54.

The means subservient to the active protection of the body are such as the organs of movement, of sight, hearing, smell, taste and touch—claws, teeth, and horns. The various powers of burrowing, climbing, swimming, diving, walking, running, hybernating, exhibit some of the different methods adapted to the differing organisations of Mammalia, and serving to protect them against a thousand and one dangers. In regard to passive structures concerned in protection we find many still among Mammalia, but in a markedly lower proportion to their multiplying needs than all that have gone before. The enumeration of the most common passive structures among Mammalia—viz. *hairy coverings* of all degrees of thickness, *spines*, *colouration* and *markings for protection*, and a few specialised forms, will show their comparative insignificance in this the highest class of animals. In truth a survey of this subject forces one to the conclusion that as animals ascend the zoological ladder they have increasingly to learn the art of living by their wits, an art which naked-skinned, unprotected man has been compelled to study to perfection, in the course of many bitter lessons.

We will here only mention the successive orders of Mammalia, as given by Lyddeker, alluding briefly to the protective character of each.

Monotremata possess fur, strong claws, and certain of them prickly spines. Marsupialia or pouched animals, such as kangaroos, wallabys and opossums, have the characteristic pouch for the young, hairy coverings, strongly-made, powerful tail, and configuration adapted to rapid leaping.

Edentata comprise sloths, ant-eaters, armadillos, and pangolins; and some have a remarkable extraneous greenish growth of fungus on their thick coarse coat, protectively coloured; ant-eaters a peculiarly tough, dense coat and hard skull; armadillos a powerful cuirass of bony plates and the power of curling up into a ball, and of burrowing rapidly. The South American apar can protect itself thus about as rapidly and efficiently on land as the "sea hedgehog" was shown to do on the water.

Sirenia, or sea-cows, with tough, smooth skin, slow in movement, frequent shallow seas, rivers and bays.

Cetacea, as whales, dolphins, porpoises, possess tough smooth skin, "blubber" for protection against cold among whales, and large, active, quickly-moving bodies.

Rodentia or gnawing animals—mice, rats, squirrels, rabbits, hares, beavers, porcupines—are mostly terrestrial, burrowing and nocturnal in habits, a few aquatic and a few arboreal. They have as defensive armour only fur as a rule, a few have spines, especially "the fretful porcupine" of Shakespeare, and, as indirect means of protection strong gnawing teeth, with hard, chisel-like, cutting edge, and no canine teeth, which would, if present, be useless to them.

Ungulata, or hoofed animals, such as horses, asses, zebras, rhinoceros, tapirs, pigs, sheep, oxen, goats, deer, antelopes, giraffes, elephants, camels, possess few passive characters—such as hairy coverings of various kinds, thickened integument, and certain special instances of protection by diverse means; and as active characters, horns, tusks, antlers on the one hand and fleetness of pace and agility—as in the horse and goat—on the other.

Carnivora, such as cats, hyænas, dogs, wolves, foxes, bears, weasels, racoons, all possess hairy coverings of great value to themselves for protection against adverse influences, also many protective markings, "vibrissæ" or "whiskers," in all the cat-tribe, a valuable tactile organ, each long hair being furnished at its base by a special sensory nerve ; the singular papillæ on the tongue of cats, *curved backwards*, for the purpose of cleaning their fur, and licking clean the bones of their prey (in which character they differ from the dog-tribe, which crush the bones with their teeth) ; the retractile claws found in many Carnivora, whose beautiful mechanism and economy of force compels our admiration. These are but a few general and special contrivances for protection among this important order of Mammalia.

Insectivora, such as hedgehogs, moles, and shrews, are inoffensive burrowing, hybernating and mostly nocturnal animals, and these show some important protective characters such as *dull uniform colouring,* strong coarse coats and formidable erectile spines among hedgehogs, delicate velvety strong coat among moles, which lies smooth when rubbed forwards or backwards, very strong claws, spade-like fore-feet, and elongated snout. Shrews show fur much like that of mice.

Cheiroptera or bats show modifications of the digits of the fore-limbs into a long framework on which is stretched the wing-membrane, enabling them to fly, the thumb being furnished with a claw, the hind-limb with hook-like claws by which the creature can suspend itself when asleep. They also have a beautifully sensitive sense of touch in the wing-membrane, nose, and external ears.

The remaining order of Mammalia, the Primates, contains lemurs, monkeys, apes and man, the least protected of all animals, except for such help as he obtains from his elevated intelligence. The armour, offensive and defensive, of the Primates below man consists of hairy coverings, some protectively coloured, strong teeth, especially tusk-teeth, prehensible tails, powerful fore-limbs, generally extreme agility of movement—all which conduce to a considerable power of taking care of themselves.

CHAPTER V

ADAPTATIONS IN THE STRUCTURE OF MAN

THE zoologist can do no less than class Man among the Primates, without reference to his origin or his destiny among the lower animals. Shakespeare's admirable description of him as "paragon of animals" agrees well with that of Huxley, who calls him a "superb animal," "head of the sentient world." He is at any rate the finished product of some wonderful power, which can hardly be Natural Selection, albeit the advocates of that theory are at liberty to trace back his ancestry through a vista of time practically boundless. Indeed there must be a vast multitude of educated persons to-day, untrammelled for various reasons by orthodox biological views, who have intimations that he "cometh from afar" in another than a Darwinian sense. Man as animal has certainly seen his best days, and the popular view of him is well put by Drummond, where he speaks of the human body as "an old curiosity shop, a museum of obsolete anatomies, discarded tools, outgrown and aborted organs," * and voiced by our popular up-to-date exponent of all existence, in his Jungle Books. Extra-scientific teachers such as these give the views of "current science" in a nutshell.

In truth, man finds himself poorly endowed with general means of protection. Having almost none of the "passive" protective structures so largely possessed by other mammals, he, the highest of all, has to depend for his safety upon such protective arrangements as his noble brain can invent. His inherited armour is trifling in its efficiency when we compare his walking, running, swimming, climbing powers, his scanty external covering of hair, his small cheek-teeth, feeble nails, and prehensile power of hand, his sense of smell, sight and hearing, with those possessed by many an animal below him in the zoological scale.

* "Ascent of Man," p. 106.

His means of protection may be divided into :

(1) Those which protect his body generally. Of these a few only can be mentioned, such as his nearly naked skin with its two million sweat-glands for defence against changes of temperature, and certain centres in his brain which regulate his body heat ; his powers of running, jumping, swimming, climbing ; his special senses ; his ability to construct weapons of offence and structures for defence such as armour, clothing, habitations. This simple statement exhausts the general means of protection except such as the heir of all the ages of civilisation can invent under the guidance of science, even to the latest form of preventive inoculation against disease.

(2) The second group of protective arrangements can only be referred to by somewhat enlarging the meaning of the word as used hitherto. It includes those anatomical arrangements of the human body which serve to protect special parts or organs. Here, no doubt, man has little to distinguish him from his nearest neighbours lower in the scale of life. Consequently, most of the

anatomical characters in this group subserving protective purposes may be taken as common to many animals mentioned in the previous chapter. This, however, will serve to throw backwards a glint of light on the special protective structures in them to which no reference has hitherto been made.

A. The long bones of the human body are constructed upon a plan, admirable for its ingenuity, if one may say so, by which a maximum of length and strength and a minimum of weight are afforded. Their tubular shafts hollowed out and filled with a light substance like the marrow, and their expanded ends of spongy tissue intersected with delicate plates placed at right angles to the surface, and tied together with secondary intersecting plates, serve to illustrate the manner in which parts so important for the activities of the body are preserved from injury, in the ordinary course of life. This arrangement of spongy tissue displays on closer examination an elaborate plan in the disposition of its every plate.* The

* Macalister, "Man physiologically considered," p. 20.

structure of bone itself, hard and dense in the shafts, and cancellous or spongy in the articular ends, manifests a combination of qualities as suitable for the purpose of support and protection as we can conceive, with an admirable economy of tissue. The smooth resilient cartilages covering the articular ends of the bones and the synovial fluid with glistening surface membrane lining the cavities of the joints, show further the contrivances adapted to secure integrity of the bones and joints. Here may be mentioned as analogous the glistening serous surfaces which line those cavities in which the heart, lungs, and abdominal organs are free to move with a minimum of friction.

B. Arteries, veins, and nerves, and large lymphatic vessels, being essential to the integrity of man's health and life, are stowed away within the limits of the human frame in a manner eminently calculated to protect them from injury. Thus in the head the arteries and veins are protected by a dense bony casing, in the neck the larger of them lie towards the front, in the region most protected from ordinary pressure and most readily guarded by eye and hand from extraordinary injury. One instance of the protection of a special nerve may be mentioned, as an illustration of the minute care shown in protection of different structures not essential to life. This is the ulnar nerve, which passes from the inner, less exposed, side of the arm behind the elbow-joint to the forearm, neatly protected as it passes the hard eminence of the joint by two bony prominences, which themselves are utilised for the attachment of muscles. The completeness of its protection is shown by the difficulty one has in finding it with the finger without some little anatomical knowledge. In the lower limbs the two great nerves are protected from pressure or injury, the sciatic nerve by an arrangement of bony projections similar to that protecting the ulnar nerve; the anterior crural nerve by its deep position in the front and inner surface of the thigh, a region which would neither encounter ordinary pressure nor be likely to be neglected by man in self-defence against injury. In contiguity to this nerve, and similarly protected, lie the main artery and vein of the limb. Towards the knee this anterior nerve has broken up into branches among the muscles, the artery and vein have wound round to the back of the limb to the hollow behind the knee, there to accompany the great posterior or sciatic nerve. In this region the great nerve, artery, and vein of the limb are branched,. and still remain carefully protected, with the exception of a large branch of the nerve which winds round the head of one of the bones of the leg, unprotected for an inch or more before it buries itself in muscles again. The protection of the arteries, veins, and nerves in the palm of the hand and sole of the foot is also very efficient.

C. The human brain is protected from all but the most serious injuries by the hard rounded skull-cap, more dense and hard in the front and back, regions where injury more frequently occurs, than at the sides of the head, where it is more rare. The spinal cord is not less safely defended by its hard bony canal filled with fluid. The heart is protected from ordinary pressure by the eneasing ribs, and from extraordinary violence by the instinctive acts calculated to guard the more defenceless anterior surface of the body. In front the lungs also are protected, and behind by closely-set ribs and thick muscular coverings.

The brain requires relief from other adverse influences than those of direct injury. Thus the varying pressure of blood in its vessels under strong mental excitement and sudden violent exertion, could not fail to damage the delicate tissue. To guard against this it is provided with what one may term an "overflow" arrangement in the highly vascular fringes of membrane, or choroid plexuses, in which a surplus of blood can be temporarily accommodated. Not only is this arranged for, but the brain rests on a delicate water-bed, so contrived that moderate jars upon the body do not convey to the brain-tissues any injurious shock. This fluid again communicates with a similar water-bed arrangement in the spinal canal by a minute pinhole opening calculated to equalise the pressure in the two cavities.

D. The essential organ of hearing is protected against any but the most severe injuries, by its deeply-set position in dense bone. The canal leading to it from the outside is protected by its shape (being curved obliquely forwards, inwards, slightly upwards, and then downwards) by its sentinel-hairs and protecting coat of wax secreted by certain glands. Against the intrusion of cold blasts of air, foreign bodies, and hostile bacteria, these arrangements supply a large measure of protection.

E. The eye is protected against injury by the hard projecting margin of the orbit, by reflex action of the lids against small foreign bodies, and its surface is lubricated by an adequate supply of fluid from glands on the lids, and the lachrymal glands. The marvellous automatic action by which small foreign bodies are steadily pushed into the inner corner and neatly lifted over a dangerous little hollow by that much despised "plica semilunaris," reputed a "vestige" of fish and reptile ancestors, needs to be noted here. In passing I may mention the case of a lady whose nerve-supply to the surface of her eyes was interfered with by disease, and who from an absence of the usual reflex mechanism would accumulate from time to time a small "rubbish heap" in this said dangerous hollow, and beneath the lower lid, giving a practical demonstration of the value of this "vestigial" fold of mucous membrane, not so noticeable in a normal eye.

In connection with the arrangements for the integrity of the eye, it is appropriate from our point of view to draw attention to a minute but significant matter. We have all, it is to be hoped, felt those tears, perhaps idle tears, which have risen to our eyes when some moving appeal has reached our emotions. We have perhaps not all inquired why it is that within one or two minutes afterwards, in any ordinary assemblage, pocket-handkerchiefs will be applied, not to the eyes, but to a neighbouring organ. This singular but familiar experience is not due, it is needless to say, to any special "sympathy" between the two parts, but to a direct conveyance of fluid from the surface of the eye to the interior of the nose, the lachrymal gland at the outer corner supplying that fluid, and a minute canal at the inner corner bringing the surplus, if not too great in quantity, to the nasal cavity. At the inner corner of each lid is visible a minute opening, which leads to a united canal passing downward through a special channel in the bones of the face, where it enlarges, and is provided with valves to prevent reflux of fluids from the nose. Small degrees of disease illustrate its value when its upper portion is occluded, and a slight constant drip of tears over the cheeks, which should be passing into the nose, is experienced. The giving way of the aforesaid valve is recognised by a bubble of air felt at the inner corner of the eye when the nose is forcibly blown. No less than three anatomical arrangements serve to direct the tears into the duct *—(1) Capillary action aided by the inward motion of the closed lids; (2) a small muscle, when the lids are closed, draws the orifices of the canal inwards and backwards, expanding the sac at the same time; (3) the circular muscle of the

* Macalister, "Text-book of Human Anatomy," p. 646.

eyelids presses downwards the tears and prevents their return.

The simplicity of this description of a small point of anatomy and its length may be pardoned, the former because it may not be known to all readers, the latter because of the extreme importance from the point of view of Design which is involved therein.

This little canal is provided with its delicate mechanism and placed where it is solely for the comfort of its possessor, and in this fact lies its importance to the teleologist. Conceive it absent from the arrangements of the eye, and the worst that would happen to man would be that the comfort and smoothness of the skin of his face would be interfered with. If man could not have learned to bear with and ignore a discomfort of this degree, it would be strange in that creature who has, more or less unmurmuringly, submitted to the mild torments of modern dress and many another physical discomfortimposed by fashion or local circumstance. Surely provision for his trifling comfort by means so delicate and complicated should make the agnostic evolutionist reflect.

The manner in which this mechanism could have rendered man or his "ancestors," from whom he may be supposed to have derived it, more adapted to his environments, were a subject more suited for discussion by Cicero's two augurs than any other persons. It is as inconceivable that natural selection can have had a hand in its origin, as in the Duke of Argyll's celebrated case of the electric organ of the torpedo.

F. There is another small canal which may be suitably linked with the nasal duct as an evidence of Design in the construction of the human body. The latter was insignificant in size and less so in survival-value, however comfortable it may be to possess a nasal duct; the former, the thoracic duct, is also insignificant in size, but of momentous importance to life. The thoracic duct, seventeen inches long, of the calibre of a crow-quill, provided with valves, has the unique function of conveying some three-fourths of the lymph of the body to the venous system. Where then is situated and how protected this valuable little life-bearing canal? Ask an anatomical student who has been set the task of displaying a dissection of this duct. He will tell you how he had to penetrate with extreme care the deepest recesses of the abdominal cavity to find it, where it lies close under the shelter of the spinal column, passing upwards into the chest alongside other vital structures, and from its deeply-buried course it emerges in the root of the neck, to join a large vein, in a position almost inaccessible to injury. However we explain the immunity of this important canal, the fact remains that injury to or pressure upon it by tumours is a phenomenon so rare as to attract immediate and unusual attention from medical men. The greatness of the survival-value of the thoracic duct is only equalled by the insignificance, from the same point of view, of the nasal duct. As evidences of Design, Contrivance, Mind, in the construction of the human body, the "infinitely great and the infinitely little" structures are of equal value.

G. Certain arrangements in the human body for its defence against injurious micro-organisms need but a short notice. Considering that Lister has shown that the air enter-ing the lungs is normally free from micro-organisms, and that St. Clair Thomson found that an average number of these organisms inspired per hour in a London atmosphere is 1200, the filtering arrangements of the hairs at the orifice of the nose, the extensive moist vascular surface of its interior, and the germicidal power of the luxuriant adenoid tissue found here and in the tonsils, must constitute a tolerably effective defence. It is only necessary to mention here the warming effect upon the inspired air of Nature's respirator !

The microbic foes which escape these first lines of defence and reach the digestive tract have still to encounter large masses of the same adenoid, germicidal tissue, distributed through the canal and called Peyer's patches. After safely evading these mechanisms of defence, certain bacteria do veritably "die in the last ditch," the third line of defence, being entangled and eliminated by the little sentinel which stands between the small and large intestines. Here is a thorny question to raise and one to which no more than a short reference can be made. The sentinel mentioned is no less than the little curled blind tube, three to four inches long, called the Appendix Vermiformis. Readers of the "Ascent of Man" are familiar with the mildly opprobrious language bestowed by Drummond upon this little "death-trap." The animosity expressed by surgeons for it is a matter of common knowledge. There is little or no evidence that Drummond or others of the despisers of the appendix recognise that it is a "death-trap" in a quite different sense from that employed by them—viz. for the microbe rather than the man. Dangers to the latter it certainly presents, but the greater the revilings it incurs, the greater the difficulty involved to the evolutionist who labels it "vestigial," and yet finds that natural selection has overlooked it in the making of the human body, otherwise so well equipped and denuded of unnecessary or inconvenient structures. Here indeed is Natural Selection arranging carefully for the delicate mechanism of the lachrymal apparatus, and at the same time neglecting a piece of finishing off profoundly important to the race! However beyond the fact that this sentinel-appendix possesses a large amount of lymphoid tissue destructive to micro-organisms, that it lies at a point in the alimentary canal where such scavenging work is eminently needed, and that more recent researches have tended to show that probably the white cells in lymphoid tissue, by secretion during their life or a substance formed in their death, yield a substance antagonistic to certain bacteria—beyond this one can say little for the "purpose" of the appendix vermiformis.

It must be frankly owned that this structure presents nearly as great a puzzle to the upholder of Design as to his opponents.

In the study of methods of protection among animals up to man, the range from the ectosarc of a Protozoon to man's preventive inoculation against disease is great indeed, revealing a wealth of "passive" and "active" arrangements for a definite purpose or end. Each and all of these are claimed as the result of a mechanical law of evolution with its primary and subordinate factors, the latter an ever-growing list. But taking the anatomy and physiology of man as we find them, and the evidence for his brute descent with its contradictory genealogical* tree full of amazing difficulties, it is hardly possible to deny that Design writ large is here, however it was brought to pass.

* See *Nature*, January 27, 1898, p. 291. Critique *re* Haeckel's "Natural History of Creation," 9th edition.

CHAPTER V

SUMMARY

THE argument for Design in Nature is much indebted to the canon of thought which Sir William Hamilton called the "law of parsimony," bidding us assume neither more nor less onerous causes for phenomena than are necessary for their production. With a principle such as this before one it is clearly improper, and unworthy of the dignity of a great truth, to ascribe to special supernatural action isolated pages of nature's story for which ascertained natural causation is forthcoming.*

* Butler shows this well in his remarks upon the word "natural," saying, "The only distinct meaning of that word is *stated*, *fixed* or *settled*; since what is natural as much requires and presupposes an intelligent agent to render it so—*i.e.* to effect i continually or at stated times—as what is supernatural miraculous does to effect it once. And from hence it must follow that persons' notions of what is natural will be enlarged in proportion to their greater

SUMMARY

It is among the glories of modern science to have made possible a comprehensive though backward view of nature ; nevertheless the very completeness and accuracy of that view serves as a foil to the impotence of science when confronted by the only creature "who looks before and after" with a request for light upon his onward path and destiny. "It is as when an hungry man dreameth, and behold he eateth ; but he awaketh and his soul is empty ; and as when a thirsty man dreameth, and behold he drinketh ; but he awaketh, and behold he is faint and his soul hath appetite." * Agnosticism is often less honest than it intends to be, and too often marked by the "What-I-do-not-know-is-not-knowledge" tone. It is commonly expounded by men of vast learning and comprehensive minds who appear to be open in their judgments, but the effect left on the minds of their readers is "I do not know," with a tacit "ergo, you do not know."

For example, it is amazing to see the

knowledge of the works of God, and the dispensations of His Providence."—Butler's "Analogy of Religion," chap. i.

* Isaiah 29, 8.

trenchant manner in which ultimate questions are disposed of by a man so eminent as Professor Karl Pearson, in a work so important as the "Grammar of Science," towards the end of which he makes the remarkable admission, "We have no right to assume that the development of man is completed," and the speculation that "correlated growth of the reasoning and perceptive faculties of man, assisted by the survival of the fittest, *may possibly have left us with a normal type of man*" (italics not in original)—a halting tone indeed for that teacher who does not hesitate to reject with scorn "the burrow of superstition" and "the ladder of metaphysics" in the pursuit of truth and to say of his foes, such as the metaphysician and philosopher: "Driven from one stronghold of ignorance, those who delight in the undisciplined imagination rather than in positive knowledge, only seek refuge in another." "Positive knowledge," indeed, for minds which may possibly be normal! and knowledge "which is, and remains throughout, provisional." * If such ideas as

* Weismann, "Germinal Selection," p. 37.

to the character of natural laws which are described as "mental shorthand," and "conceptual formulæ," "the product of the human mind," &c., be accepted, science itself must ever be in the nature of scaffolding for some edifice which is never to be displayed. The *impasse* in all this is so striking that in France "the bankruptcy of science" is a familiar idea; the theory of evolution is relegated from the province of pure science to that of "Logic: Chapter, Hypothesis" in the Syllabus for the B.A. examinations, and is left to be dealt with by philosophy. It is this eminently logical nation which is shrinking from the practical application of the theory of evolution to human life as expounded by M. Zola. The writings of M. Brunetière, the mouthpiece of the University of Paris, may be taken in illustration.* It may be replied that this is only a French view of the position. But the opposite view is only that of England and

* "Now in the present state of science, and after the trial we have given it, the question of the freedom of the will, for instance, or that of moral responsibility, could not be solved by, or depend upon, the results of physiology. The progress which we thought we had made with Taine

Germany and America, which for the present are under the sway of this "indefinite and confused movement of the mind of the age."

When it is remembered that with all his devotion to Darwinism, Professor Weismann felt compelled, in view of the "many doubts which have gathered round it like so many thunder-clouds," to invent his newest theory of Germinal Selection, so as "to rehabilitate the principle of selection," and when the great crucial test as to this theory, that of *experiment*, is almost absent, being represented by such investigations as those of Professor Weldon on the measurements of the frontal breadth of shore-crabs, there is little wonder that neither in this country nor in France are "biological ethics" put to the test of experiment by allowing such social reformers as Professor Karl Pearson to attempt the production of "a fitter regulative system" than the jurisprudence of these countries affords.

in joining moral science to natural science (*i.e.* physiology, &c.), was not at all a progress, but, on the contrary, a retrogression. If we deduce from Darwinism lessons in morality, it would only teach us abominable precepts.'
—*Revue des Deux Mondes*, January 1895.

Let the scientist at present disclaim, as he does, the consideration of all ultimate questions, yet he cannot prevent, and indeed has not prevented, their transference to the bar of the philosopher. Up to the last Darwin himself seemed to favour Design of a certain broad kind in animated nature, as shown by his references to certain primordial forms of life into which the Creator may have breathed the breath of life, and by his maintenance of singularly teleological quotations from Butler, Whewell and Bacon as headings for his "Origin of Species."

To-day many will only follow Darwinian leadings if they are able to hold a determinate or directed evolution. To others still it seems more sound to avoid putting the new wine of Darwinism with all its stirring, ever-changing life fresh upon it into the old bottles of Design. To such, Darwinism, with struggle, heredity, survival, selection as its potent factors, is to be rather looked upon as an enduring glow of light upon the *maintenance* of living things on the globe than as an interpretation of their production.

The fact is that the great teachers of

evolutionary doctrines such as Darwin, Huxley, Weismann, with their "laws impressed on matter by the Creator," their "wider teleology," their "everything adapted in animate nature," and "*the useful variation always present*," can by no means get rid of the old leaven of Design in nature. It may be remembered how in 1806 a certain decree was issued from Berlin by which the great Napoleon placed the British Isles in a state of blockade: but it was "impossible even for Napoleon himself to do without the goods he pretended to exclude. The French army which marched to Eylau was clad in great-coats made at Leeds and shod with shoes made at Northampton." * And now in 1897 another decree has issued, this time from Freyburg, placing the teleologist outside the pale of science under scientific blockade, in the notable remark upon teleological principles: "Their introduction, however, is the ruin of science." †

The mechanical and teleological systems of philosophy stand over against one another

* Green, "History of the English People."

† Weismann, "Germinal Selection," pref. xii.

in profound contrast, if not opposition, and the latter, with such modern advocates as Professors Campbell Fraser, Andrew Seth, and James Ward, may well hold its head erect till its full vindication arrives. Let Professor Seth be heard as to his deliberate conviction regarding these two rival groups. "There is nothing of which I am more profoundly convinced than that philosophical truth lies, in this case, altogether with the teleological point of view." * To the mechanical philosopher: "The earth, with Man upon it, does not seem much more than an ant-hill, where some ants carry corn, and some carry their young, and some go empty, and all to and fro a heap of dust."

His outlook upon creation is well compared by Edward Thring, of Uppingham, to that of the man who tries to understand the plan of a field of young wheat, which is all confusion and entanglement to him as long as he looks crossways aslant the furrows; while to the teleologist all creation is as a seed-plot of life, sowed and set in order by

* Andrew Seth, "Man's Place in Nature," p. 57

Infinite Wisdom, interpreted, in growing measure, as the field of wheat is by him who will look from the end of the furrows, from the sower's point of view.

In the limited sphere of protection it has now been pointed out that plants and animals up to man are endowed with adequate protective characters adapted to the most diverse needs, and that economy in their supply is closely observed.

A glimpse has been given of the exceeding variety and ingenuity of contrivance for protection, revealed in the living things around us. Is it conceivable that anything but high intelligence in operation can have produced the protective arrangements — adequate, varied, and temporary—of a horse-chestnut, the delicate hairs provided for the carriage of wind-borne seeds, the strange protection conferred upon the "monkey-puzzle," the "overcoat" of a freshwater mollusc, the spider's web, the spines and distensible skin of a globe-fish, the long rapier of the sword-fish, the saw of the saw-fish, the electric organ in a skate's tail, the fishing-tackle of the angler-fish, the oil-sac of aquatic birds, the protective vegetable growth on a sloth's hair, the poison-apparatus of a snake? Apparently it *is* conceivable, for there are biologists such as Professor Haeckel,* or physiologists such as Professor Leonard Hill,† who meet any special cases of this kind in a very summary manner by virtually attributing them to reason, choice or free will on the part of the organism. Indeed, it is not many years since Professor Haeckel held the opinion that the formation of a crystal from a saline fluid was a process of life of the same nature as the growth of a plant or the intelligence of a man. Crystals presumably were, then at least, endowed with free will of the kind that Professor Leonard Hill claims for bacteria now. To the majority of minds such logical following out of his principles tends very nearly to the disproof of the position of the Agnostic evolutionist by the process known as "reductio ad absurdum."

It has also been maintained that from the dawn of life to the human period the ascend-

* "The Last Link," p. 130–134.

† "Manual of Human Physiology," p. 63.

ing series of vegetable and animal forms found ready such environments as they needed, and that these in many cases were prepared long ages before their occupants arrived. The conditions for his life which man, whenever and however he came upon the scene of his unique career, found provided and placed within his reach, may be taken as illustrative of those required and found by the simpler forms of life below him.

He found himself possessed of a body capable of a vast range of adaptation to physical conditions which has carried him from the Arctic Circle to the Southern Seas, with a specific gravity which should not of necessity make him sink in water, with a brain capable of devising endless varieties of inventions for his benefit. He found such an atmosphere as he needed for his life, both as to bulk and composition, a mantle of fruitful soil upon the crust of the earth, made ready by the physical and chemical processes of bygone days, and this soil broken up and enriched by the labours of myriad earthworms. He found a due proportion of land

and sea with varying climate and seasons, a rainfall of varying but bearable amount. He found, ready for his growing intelligence to cultivate, those plants which became the cereals of to-day, with edible fruits and seeds without number. He found the Ungulate and Carnivorous animals which his dawning sense of need might domesticate for his use. He found supplies of wood for his higher needs, of coal and valuable metals for his arts, in the earth's crust. He found, though he knew it not, an untold host of bacteria of putrefaction, without which neither the land nor water would have been inhabitable. He found also micro-organisms which he could and did unwittingly domesticate for the production of many articles of food, such as bread, butter, cheese and fermented liquors, a process known as "microscopic gardening."

The Design in Nature's story is equally proclaimed, by bacteria of putrefaction, and the provision of a suited atmosphere for this planet.

Two propositions stand out before us practically unchallenged :

(1) "Everything is adapted in animate nature and has been from the first beginnings of life."

(2) "Inanimate nature on this planet is adapted for animate nature and has been from the first beginnings of life."

There is one further point in the controversy as to Design in Nature to which attention may once more be directed. It is one early brought forward by Darwin and held by his followers as an argument of overwhelming weight against supernatural Design. Darwin invited his opponents to adduce a single instance in the vegetable or animal kingdom of a structure or an instinct which should be shown for certain to be of exclusive use to any other plant or animal than the one presenting it, and committed himself to the bold statement that he would surrender his whole theory of Natural Selection upon the production of a single true instance of this occurrence. He was so assured of the truth of his theory that he could not accept for a moment the belief that Natural Selection could ever have *permitted* (*sic*) an adaptive structure or instinct to occur in one species for the exclusive benefit of another. Others have followed in the same strain, and the gage of battle is supposed to be lying where Darwin threw it forty years ago.

Romanes * even carried this argument and challenge further, thinking that Darwin did not make a sufficient weight of evidence from this point. He triumphantly supposed it to be unanswered and unanswerable, and his remarks upon it are highly interesting. The only two instances in all the millions of vegetable and animal structures of adaptation which he would consider, and these he firmly set aside, are the sweet secretion of aphides which ants cultivate for their own advantage—a case produced by Darwin himself and disallowed—and the formation of vegetable galls, which are of value to the nurture and protection of the larvæ of insects. This case Romanes also set aside as explicable by natural means, or, failing this, as the result of accident.

Milnes Marshall in his lectures on the Darwinian theory also disposes of this argu-

* "Darwin and after Darwin," vol. i. pp. 286–295.

ment in a very summary fashion. He says: * "That there is evidence that any animals or plants are specially designed to satisfy the wants or to delight the senses of man is most absolutely denied, and could such cases be proved, they would be fatal to the whole theory. In nature these characters alone are preserved which are advantageous to the species." But this old and fair argument on behalf of the evolutionist, and against the teleologist, is not to be disposed of in this summary style. We are not shut up to a few trifles such as the "milk" of aphides or vegetable galls. If the argument be put forward at all we cannot be forced into a corner, dazzled with the light of a great name and learning, and deprived of our weapons of defence—or offence—without a little preliminary struggle in the open. What right has Darwin, Romanes, or Milnes Marshall to demand that we accept the arbitrary terms in this duel which they chose to offer? What right have they to demand that we show single adaptive structures or instincts, which are for the

* "Lectures on the Darwinian Theory," 1894, p. 171.

exclusive use of other species? Is this the kind of peddling to which a Divine Being, concerned in the age-long production and superintendence of the inhabited world we see around us, can be supposed to have condescended? Romanes himself, in the heat of his triumph, furnished us with a passage of noble insight as to what might have been had beneficent design been the rule of the universe.* We might even present him with the beneficent action upon the soil of the earthworm and white ant, but prefer to leave aside such details. Species indeed! And why species only? And why not genus, order, family, class, sub-kingdom and kingdom? What possible claim can even the greatest naturalist the world ever saw yet have upon the terms of controversy, that he

* He said, "For how magnificent a display of divine beneficence would organic nature have afforded if all—or even some—species had been so inter-related as to have ministered to each other's wants. Organic species might then have been likened to a countless multitude of voices, all singing in one great harmonious psalm. But, as it is, we see absolutely no vestige of such co-ordination: every species is for itself, and for itself alone—an outcome of the always and everywhere fiercely raging struggle for life."—"Darwin and after Darwin," p. 288.

and his followers shall lay down impossible terms, and then blandly proclaim that the battle goes by default ?

If we wish to give full weight to the objection here raised to the argument for Design in Nature, we have a wider, a greater, a more unimpeachable witness than aphides and galls. We hardly need to dwell upon the admitted fact that in the realm of nature the vegetable world stands in a position intermediate between inorganic nature and the animal kingdom. As the globe is constituted, were it not for plants, animals would never have been or continued to be. Plants alone can extract nutriment from the soil, and by their life and death supply for animals the needed protoplasm. And, with little exception in earth, water or air, animals live by the beneficent silent work of the present or past life of plants. It were wearisome to elaborate this well-known fact of nature. The simple fact remains, and no scientific explanations of the "natural" laws under which it takes place touch for an instant its striking value as a broad argument for Design in Nature. We have passed beyond species and genera to a vast food-factory for the whole animal creation of surpassing complexity and profusion, pervaded by evidences of mind and will, one-thousandth part of which in a nineteenth-century factory would excite our highest admiration. The objections of Darwin, Romanes, and Milnes Marshall, by the very earnestness of the challenge, and the magnitude of the answer afforded by the whole vegetable kingdom, constitute a body of evidence against the blind mechanical force which they deify of obvious cogency. They do but add materially to the weight of all that has here been put forward in favour of Design in Nature's Story.

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